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Standards of performance for the control of emissions from lead-acid battery manufacturing plants are being proposed under the authority of section 111 of the Clean Air Act. These standards would apply to new, modified, or reconstructed facilities at any lead-acid battery manufacturing plant with a production capacity equal to or greater than 500 batteries per day. This document contains background information, environmental and economic impact assessments, and the rationale for the standards, as proposed under 40 CFR Part 60, Subpart KK.

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Don R. Goodwin, Director
Emission Standards and Engineering Division
U. S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Approved by:

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(Date)

for David G. Hawkins
Assistant Administrator for Air,
Noise and Radiation
U. S. Environmental Protection Agency
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1.0 SUMMARY

1.1 PROPOSED STANDARDS

The proposed standards would limit atmospheric lead emissions from new, modified, or reconstructed facilities at any lead-acid battery manufacturing plant which has a production capacity equal to or greater than 500 batteries per day (bpd). The facilities which would be affected by the standards, and the proposed emission limits for these facilities are listed below:

Facility	Lead Emission Limit
Lead-oxide production	5.0 mg/kg (0.010 lb/ton)
Grid casting	0.05 mg/m^3 (0.00002 gr/dscf)
Paste mixing	1.00 mg/m^3 (0.00044 gr/dscf)
Three-process	1.00 mg/m^3 (0.00044 gr/dscf)
Lead reclamation	2.00 mg/m^3 (0.00088 gr/dscf)
Other lead-emitting operations	1.00 mg/m^3 (0.00044 gr/dscf)

The emission limit for lead-oxide manufacture is expressed in terms of lead emissions per kilogram of lead processed, while those for other facilities are expressed in terms of lead concentrations in exhaust air.

In addition, 0 percent opacity standard is proposed for emissions from any of these affected facilities. The proposed standards would also require continuous monitoring of the pressure drop across the control system, to help insure proper operation of the system. Performance tests would be required to determine compliance with the proposed standards. A new reference method, Method

12, would be used to measure the amount of lead in exhaust gases, and Method 9 would be used to measure opacity. Process monitoring would be required during all tests.

The Administrator considered setting standards of performance for the lead-acid battery manufacturing industry which would limit sulfuric acid mist emissions, as well as atmospheric lead emissions. Thus, the emission control alternatives discussed in this Document include the use of mist eliminators to control acid mist emissions from dry formation operations. Sulfuric acid mist standards are not being proposed at this time, however.

1.2 SUMMARY OF ENVIRONMENTAL, ENERGY, AND ECONOMIC IMPACTS

New, modified and reconstructed facilities coming on-line over the next five years will emit about 95 Mg (104 tons) of lead to the atmosphere in the fifth year, if their emissions are controlled only to the extent required by State particulate regulations. At some existing plants, emissions are controlled to a greater extent than state particulate regulations require. This practice might be continued at new plants in the absence of the proposed standards of performance. The proposed standards would reduce potential lead emissions from facilities coming on-line during the next five years to about 2.8 Mg (3.1 tons) in the fifth year. This is approximately 97 percent lower than the emission level which would be allowed under state particulate regulations. The proposed standards would also result in decreased nonlead particulate emissions from new plants, since equipment installed for the purpose of controlling lead-bearing particulate emissions, would also control nonlead-bearing particulate emissions.

The results of dispersion modeling calculations indicate that the ambient atmospheric lead standard of 1.5 $\mu g/m^3$ (averaged over a calendar quarter) will be met at plants compl-ing with the proposed standards. This is an important consideration, since most lead-acid battery plants are located in urban areas. Results of EPA dispersion modeling calculations indicate that the ambient lead standard will not be met in the neighborhoods of plants controlling emissions only to the extent required by existing state regulations.

The impact of the proposed standards on the wastewater and solid waste emissions of a lead-acid battery plant would depend on the technique used by that plant to comply with the proposed standards. The best demonstrated system for reduction of lead emissions is the use of fabric filters. High energy impingement scrubbers could also be used, but would have higher energy requirements and operating costs than fabric filters. At plants using impingement scrubbing to control emissions, lead-bearing wastewater would be generated. This would be treated along with other plant wastewater prior to being disposed from the plant. The fractional increase in the lead content of wastewater discharged from a plant using impingement scrubbing to control all atmospheric lead emissions except those from the three-process and lead oxide production facilities would be about 4.5 percent. At plants using fabric filtration to comply with the proposed standards, the captured pollutant would be reclaimed, and there would be no increase in wastewater or solid waste emissions due to the proposed standards.

The energy needed to operate control equipment required to meet the proposed standards at a new plant would be approximately 2 percent of the total energy needed to run the plant. The incremental energy demand resulting from the application of the proposed standards to the battery manufacturing facilities expected to come on-line over the next five years would be about 2.8 Gigawatt hours of electricity in the fifth year. Approximately 4.8 thousand barrels of oil would be required to generate this electricity.

The capital cost of the installing emission control equipment necessary to meet the proposed standards on all new facilities coming on-line nationwide during the first five years of the standards would be approximately $8.6 million. The total annualized cost of operating this equipment in the fifth year of the proposed standards would be about $4 million.

These costs and energy and environmental impacts are considered reasonable, and are not expected to prevent or hinder expansion of the lead-acid battery manufacturing industry. Economic analysis indicates that, for plants with capacities larger than or equal to 500 bpd, the costs attributable to the proposed standards could be passed on with little effect on sales. The average incremental cost associated with the proposed standard would be about 30¢ per battery. This is about 1.6 percent of the wholesale price of a battery.

2. INTRODUCTION

Standards of Performance are proposed following a detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This document summarizes the information obtained from such a study. It s purpose is to explain in detail the background and basis of the proposed standards and to facilitate analysis of the proposed standards by interested persons, including those who may not be familiar with the many technical aspects of the industry. To obtain additional copies of this document or the Federal Register notice of proposed standards, write to EPA Library (MD-35), Research Triangle Park, North Carolina 27711. Specify "Lead-Acid Battery Manufacturing, Background Information: Proposed Standards," document number EPA 450/3-79-028a when ordering.

2.1 AUTHORITY FOR THE STANDARDS

Standards of performance for new stationary sources are established under section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, hereafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect, ". . . the degree of emission limitation achievable through the application of the best technological system of continuous emission reduction . . . the Administrator determines has been adequately demonstrated." The Act also provides that the cost of achieving the necessary emission reduction, the nonair quality health and environmental impacts and the energy requirements all be taken into account in establishing standards of performance. The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions which apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources which have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

25 percent of the listed categories by August 7, 1980
75 percent of the listed categories by August 7, 1981
100 percent of the listed categories by August 7, 1982

A governor of a State may apply to the Administrator to add a category which is not on the list or may apply to the Administrator to have a standard of performance revised.

2. EPA is required to review the standards of performance every four years, and if appropriate, revise them.

3. EPA is authorized to promulgate a design, equipment, work practice, or operational standard when an emission standard is not feasible.

4. The term "standards of performance" is redefined and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low-polluting or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under section 111 of the Act may be extended to six months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental empact and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under section 116 of the Act to establish even more stringent emission limits than those established under section 111 or those necessary to attain or maintain the national ambient air quality standards (NAAQS) under section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area which falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term "best available control technology" (BACT), as defined in the Act, means ". . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of 'best available control technology' result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 or 112 of this Act."

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling, and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require, or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare or safety; (4) the governor of the State where the source is located consents; and that, (5) the waiver will not prevent the atttainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to three years to meet the standards, with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources which have not been listed before. The Adminstrator, ". . . shall include a category of sources in such list if in his judgement it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow while adhering to the schedule referred to earlier.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are emitted by stationary sources. Source categories which emit these pollutants were then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might be required from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of performance for the source category. Sources for which new source performance standards were promulgated or are under development during 1977 or earlier, were selected on these criteria.

The Act amendments of August, 1977, establish specific criteria to be used in determining priorties for all source categories not yet listed by EPA. These are

1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit;

2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and

3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

In some cases, it may not be feasible to immediately develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, determining the types of facilities within the source category to which the standard will apply must be decided. A source category may have several facilities that cause air pollution and emissions from some of these facilities may be insignificant or very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there be no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, and the nonair quality health and environmental impacts and energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best technological system of continuous emission reduction which has been adequately demonstrated. The legislative history of section 111 and various court decisions make clear that the Administrator's judgement of what is adequately demonstrated is not limited to systems that are in actual routine use. The search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. In most cases, determination of the ". . . degree of emission reduction achievable . . ." is based on results of tests of emissions from well controlled existing sources. At times, this has required the investigation and measurement of emissions from control systems found in other industrialized countries that have developed more effective systems of control than those available in the United States.

Since the best demonstrated systems of emission reduction may not be widespread use, the data base upon which standards are developed may be somewhat limited. Test data on existing well-controlled sources are obvious starting points in developing emission limits for new sources. However, since the control of existing sources generally represent retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered before a judgement can be made as to the level at which the emission standard should be set.

A process for the development of a standard has evolved which takes into account the following considerations.

1. Emissions from existing well-controlled sources as measured.

2. Data on emissions from such sources are assessed with consideration of such factors as: (a) how representative the tested source is in regard to feedstock, operation, size, age, etc.; (b) age and maintenance of control equipment tested; (c) design uncertainties of control equipment being considered; and (d) the degree of uncertainty that new sources will be able to achieve similar levels of control.

3. Information from pilot and prototype installations, guarantees by vendors of control equipment, unconstructed but contracted projects, foreign technology, and published literature are also considered during the standard development process. This is especially important for sources where "emerging" technology appears to be a significant alternative.

4. Where possible, standards are developed which permit the use of more than one control technique or licensed process.

5. Where possible, standards are developed to encourage or permit the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.

6. In appropriate cases, standards are developed to permit the use of systems capable of controlling more than one pollutant. As an example, a scrubber can remove both gaseous and particulate emissions, but an electrostatic precipitator is specific to particulate matter.

7. Where appropriate, standards for visible emissions are developed in conjunction with concentration/mass emission standards. The opacity standard is established at a level that will require proper operation and maintenance of the emission control system installed to meet the

concentration/mass standard on a day-to-day basis. In some cases, however, it is not possible to develop concentration/mass standards, such as with fugitive sources of emissions. In these cases, only opacity standards may be developed to limit emissions.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires, among other things, an economic impact assessment with respect to any standard of performance established under section 111 of the Act. The assessment is required to contain an analysis of:

(1) the costs of compliance with the regulation and standard including the extent to which the cost of compliance varies depending on the effective date of the standard or regulation and the development of less expensive or more efficient methods of compliance;

(2) the potential inflationary recessionary effects of the standard or regulation;

(3) the effects on competition of the standard or regulation with respect to small business;

(4) the effects of the standard or regulation on consumer cost; and,

(5) the effects of the standard or regulation on energy use.

Section 317 requires that the economic impact assessment be as extensive as practible, taking into account the time and resources available to EPA.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing State control regulations. An incremental approach is taken since both new and existing plants would be required to comply with

State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that exists between a standard of performance and the typical State standard.

The costs for control of air pollutants are not the only costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absense of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry, as this factor also influences the ability of new plants to generate the capital required for installation of additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performances for various industries, the Federal Courts of Appeals have held that environmental impact statements need not be prepared by the Agency for proposed actions under section 111 of the Clean Air Act. Essentially, the Federal Courts of Appeals have determined that ". . . the best system of emission reduction, . . . require(s) the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. . ." On this basis, therefore, the Courts ". . . established a narrow exemption from NEPA for EPA determination under section 111."

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969."

The Agency has concluded, however, that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, while not legally required to do so by section 102(2)(C) of NEPA, environmental impact statements are prepared for various regulatory actions, inlcuding standards of performance developed under section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is included in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are identified and discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new sources as ". . . any stationary source, the construction or modification of which is commenced . . . " after the proposed standards are published. An existing source becomes a new source if the source is modified or is reconstructed. Both modification and reconstruction are defined in amendments to the general provisions of Subpart A of 40 CRF Part 60 which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416). Any physical or operational change to an existing facility which results in an increase in the emission rate of any pollutant for which a standard applies is considered a modification. Reconstruction, on the other hand, means the replacement of components of an existing facility to the extent that the fixed capital cost exceeds 50 percent of the cost of constructing a comparable entirely new source and that it be technically and economically feasible to meet the applicable standards. In such cases, reconstruction is equivalent to a new construction.

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under section 111(d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under section 108 or which has not been listed as a hazardous pollutant under section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3.0 THE LEAD-ACID BATTERY INDUSTRY

3.1 GENERAL

The largest single use of lead in the United States is in the manufacture of lead-acid, or secondary, storage batteries. There are approximately 190 lead-acid battery plants in the United States, of which 91 have been estimated to be small plants.[1] The six largest companies, with branch plants distributed across the country, account for over 70 percent of the lead-acid battery market.

Lead-acid battery plants are scattered throughout the country, and are generally located in highly urbanized areas near markets for their batteries. Some of the larger plants have secondary smelting facilities, or lead oxide production facilities, or both; smaller firms tend to purchase the lead constituents from outside vendors.

3.1.1 Industry Profile

Two major types of lead-acid storage batteries are manufactured in the United States: 1) Starting-lighting-ignition (SLI) batteries, used in automobiles, golf carts, and aircraft, SIC (Standard Industrial Classification) 36911, and 2) industrial storage batteries for low-voltage power systems, industrial fork-lift trucks, and the like, SIC 36912. SLI units account for more than 80 percent of the market.[2]

3.1.1.1 Relationship of Battery Industry to Overall Economy--

Lead-acid battery shipments in 1974 were valued at $1.15 billion,[3] accounting for 0.08 percent of the 1974 gross national product (GNP) of

$1397 billion.[4] Annual battery values and the GNP for the period 1960 to 1974 are presented in Figure 3-1, which also depicts the added value (shipment value minus raw material value).

The gross national product and lead-acid battery values have shown similar trends since 1960, both increasing approximately 280 percent. Total use of lead by battery manufacturers increased 235 percent during the 14-year period beginning in 1960.[5] The lead-acid battery industry employed 22,100 workers in 1972.[6] New battery plant and equipment expenditures for 1972 amounted to $30.8 million.[7] Of this amount, new machinery and equipment accounted for $21.1 million.[8]

3.1.1.2 Relationship of Battery Industry to Lead Industry--

The battery industry receives lead from two sources: mines and secondary lead smelters. The storage battery industry consumed 0.77 Tg (850,000 tons) of lead in 1974.[9] United States mine production of recoverable lead in 1975 was 0.56 Tg (620,000 tons).[10] Estimated secondary lead recovery in 1975 was 0.55 Tg (610,000 tons).[11] Scrapped lead-acid batteries account for the major portion of recovered lead, along with drosses and residues (lead-containing wastes and impurities that are processed to recover lead). Approximately 0.17 Tg (190,000 tons) of imported lead constitute the remainder of lead supplied to the industry in 1975.[12]

Lead consumption by individual products in the years 1971 through 1975 is summarized in Tables 3-1 and 3-1A. Lead storage batteries accounted for almost 0.64 Tg (700,000 tons), or more than half of the total lead consumed in 1975.[13] Metal grids and posts required 0.30 Tg (327,000 tons), while 0.34 Tg (373,000 tons) of lead was used in lead oxide for grid pasting.[14]

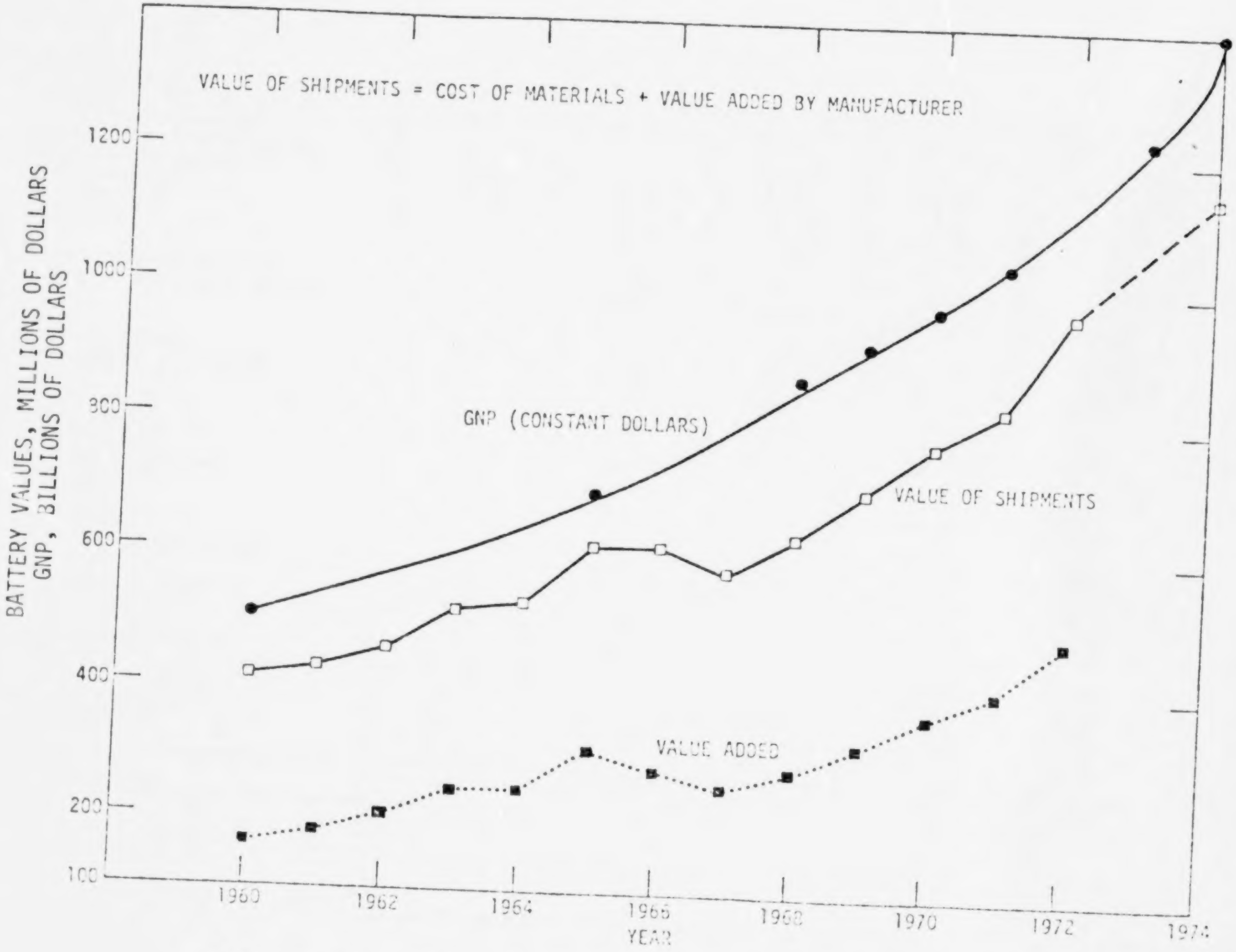

Figure 3-1. Trends in lead-acid battery shipments and in gross national product.

Table 3-1. UNITED STATES CONSUMPTION OF LEAD[18,19]

(in Gigagrams)

	1971	1972	1973	1974	1975
Ammunition	79.4	76.8	73.9	79.0	68.1
Bearing metals	14.8	14.4	14.2	13.3	11.1
Brass and bronze	18.2	18.0	20.6	20.1	12.2
Cable covering	48.0	41.7	39.0	39.4	20.0
Calking lead	27.2	20.4	18.2	17.9	13.0
Casting metals	6.6	8.5	6.5	6.8	7.0
Collapsible tubes	9.1	3.6	2.6	2.3	2.0
Foil	4.0	4.2	4.5	4.0	2.9
Pipe, traps and bends	16.5	16.1	19.3	14.9	12.9
Sheet lead	25.0	21.5	21.2	19.3	22.6
Solder	63.5	64.7	65.1	60.1	62.0
Storage batteries	616.7	659.2	698.0	772.8	634.5
Terne metal	1.3	0.5	2.4	2.1	1.4
Type metal	18.9	18.1	19.9	18.6	14.7
White lead	4.3	2.6	1.3	1.8	2.3
Red lead and litharge	56.1	63.3	81.2	87.2	59.3
Pigment colors	12.6	14.8	15.4	15.7	9.6
Other	0.7	0.3	0.4	0.7	0.2
Gasoline antiknock additives	239.7	252.5	248.9	227.3	189.2
Miscellaneous chemicals	0.4	0.8	0.9	0.6	0.2
Annealing	3.7	3.9	3.6	3.7	2.4
Galvanizing	1.3	1.3	1.2	1.5	1.1
Lead plating	0.5	0.6	0.7	0.5	0.3
Weights and ballast	15.8	19.3	18.9	19.4	18.2
Other uses unclassified	14.3	22.5	19.7	21.9	19.3
TOTAL	1,298.6	1,349.6	1,397.6	1,450.9	1,186.8

Table 3-1A. UNITED STATES CONSUMPTION OF LEAD[18,19]

(in short tons)

	1971	1972	1973	1974	1975
Ammunition	87,567	84,699	81,479	87,090	75,081
Bearing metals	16,285	15,915	15,657	14,609	12,184
Brass and bronze	20,044	19,805	22,735	22,240	13,404
Cable covering	52,920	45,930	43,005	43,426	22,099
Calking lead	29,993	22,483	20,057	19,739	14,296
Casting metals	7,281	7,139	7,220	7,507	7,711
Collapsible tubes	10,041	4,020	2,860	2,488	2,216
Foil	4,417	4,592	4,985	4,404	3,205
Pipe, traps and bends	18,174	17,780	21,291	16,455	14,233
Sheet lead	27,607	23,667	23,394	21,294	24,859
Solder	70,013	71,289	71,770	66,280	57,344
Storage batteries	679,803	726,592	769,447	851,881	699,414
Terne metal	1,409	504	2,658	2,300	1,511
Type metal	20,812	19,944	21,922	20,516	16,211
White lead	4,731	2,814	1,479	1,996	2,498
Red lead and litharge	61,838	69,799	89,577	96,163	65,457
Pigment colors	13,916	16,264	16,963	17,336	10,618
Other	773	377	477	718	499
Gasoline antiknock additives	264,240	278,340	274,410	250,502	208,605
Miscellaneous chemicals	401	849	944	708	181
Annealing	4,068	4,329	3,974	4,097	2,629
Galvanizing	1,395	1,397	1,294	1,664	1,228
Lead plating	582	638	744	498	376
Weights and ballast	17,453	21,302	20,848	21,418	20,018
Other uses unclassified	15,751	24,826	21,749	24,098	21,221
TOTAL	1,431,514	1,485,254	1,541,209	1,599,427	1,297,098

3.1.1.3 Battery Usage and Sales Forecast--

Total battery shipments of 54.5 million SLI units in 1974 represented the first annual decline since 1967.[15,16] Figure 3-2 shows the shipments of SLI units (replacement, original equipment, and imported batteries) since 1947. Shipments of replacement units remained relatively constant. The decline in new car sales accounted for the total decrease.

Table 3-2 summarizes SLI battery use. SLI units account for 80 percent of the total lead-acid battery market in 1974.[17] Industrial batteries account for the remaining 20 percent. Approximately 80 percent of the SLI units are used in automobiles.[22]

TABLE 3-2. SUMMARY OF SLI BATTERY USE: 1974[23]

Classification	Portion of SLI market, %
Automobile	80
Heavy duty/commercial	14
Golf carts	2
Light utility	2
Marine	1
Miscellaneous	1

Several sources provide forecasts for the lead-acid battery industry. One of the trade organizations for this industry, the Battery Council International (BCI), predicts an annual growth rate of approximately 3 percent through 1979.[24] Another source estimates an average employment increase of 2.4 percent per year in the storage battery industry through 1985.[25]

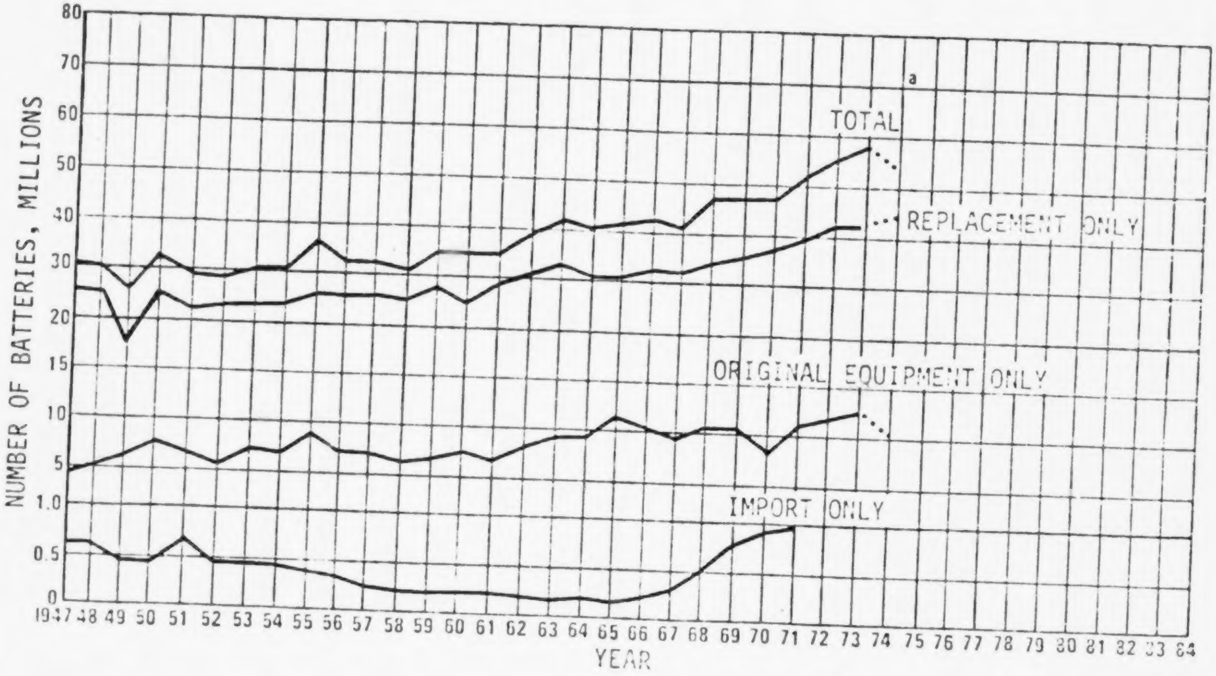

Figure 3-2. United States shipments of SLI lead-acid batteries from 1947 to 1974.[20,21]

3.1.1.4 Industry Expansion--

Quantitative information and estimates regarding industry expansion are not available in the literature at the present time. The decline in new car sales and the economic slump in the mid-1970's have caused uncertainty concerning industry growth, as have the increased activities of regulatory agencies such as OSHA and EPA. The result is a very nebulous picture concerning plant modification and new plant construction.

One source projects an annual growth rate of 5 percent.[26] Estimates of growth rate obtained from those plants responding to EPA inquiry (Section 114 Letters)* range from 40 to 120 percent through 1985, yielding a projected average annual rate of 3.5 to 8.2 percent. The BCI agrees with the lower estimate.[27]

The BCI report states that the sales increase for 1975 should be nil. The forecast for 1976 is a 4 percent gain, and for the remaining years, 1977 through 1979, a 3.7 percent gain. Thus, BCI projects a 3 percent annual growth rate over the next 5 years.[28]

Responses to EPA's Section 114 Letters indicated that nearly all growth would be realized through expansion of existing, larger plants, those with capacities of 2000 batteries per day (bpd) or more.

3.1.2 Process Description

A lead-acid battery consists of any number of cells, depending on the voltage rating of the battery. Stationary batteries contain up to 120 cells (240 volts), whereas automobile batteries generally contain 3 or 6 cells (6 or 12 volts). Lead acid storage batteries range in size and weight. It is estimated that an average battery weighs 18.1 kg (40 lb), of which 11.8 kg (26 lb) is lead. The electrodes are made of lead, and the electrolyte consists of a solution of sulfuric acid and water. The cathode consists of lead peroxide and the anode consists of porous or spongy lead. Both the anode and the cathode are converted to lead sulfate when the battery is discharging. Many complicated chemical reactions take place inside a lead-oxide battery during discharge, resulting in neutralization of the two plates and weakening of the electrolytic solution by formation of water. Figure 3-3 shows the components of a battery.

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*These are etters sent to various manufacturers of lead acid batteries by which certain information is sought to assist EPA in developing standards of performance. Authority for requiring disclosure of information for this purpose is vested in the Administrator of EPA under Section 114 of the Clean Air Act. Hence these letters are referred to as "114 Letters."

The electrodes, or plates, consist of two parts: (1) an inactive lead grid, which provides mechanical support for the active portion (the plate) and a conductive path for the electric current, and (2) a lead oxide sulfate paste, which is applied and bonded to the grids. Other materials in the lead-acid battery include plastic, wood, or rubber separators and the outer case materials, which are usually vulcanized rubber, polypropylene, nylon, or acrylics. Figure 3-4 shows the arrangement of battery components in an element.

Consumer attention has recently been directed toward the waterless or "maintenance free" batteries. These batteries are typically supplied without vent plugs or provisions for adding water. Though they appear to be totally sealed, they are always vented in some way, usually by small holes in the top of the battery case. These batteries are practically identical to the conventional battery except in appearance; they all use lead-lead peroxide plates in a sulfuric acid electrolite. There are

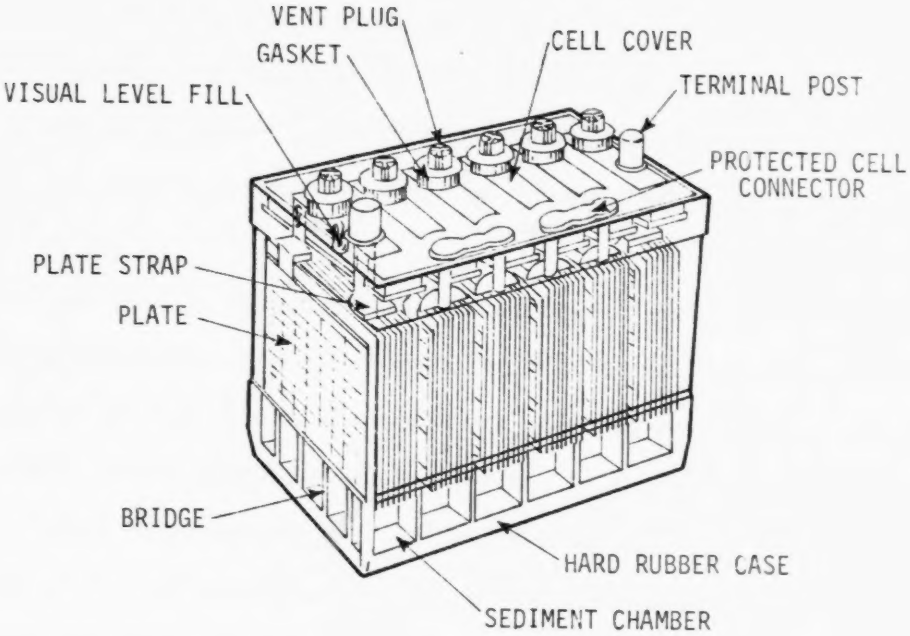

VENT PLUG
GASKET
CELL COVER
VISUAL LEVEL FILL
TERMINAL POST
PROTECTED CELL CONNECTOR
PLATE STRAP
PLATE
BRIDGE
HARD RUBBER CASE
SEDIMENT CHAMBER

Figure 3-3. A lead-acid storage battery.

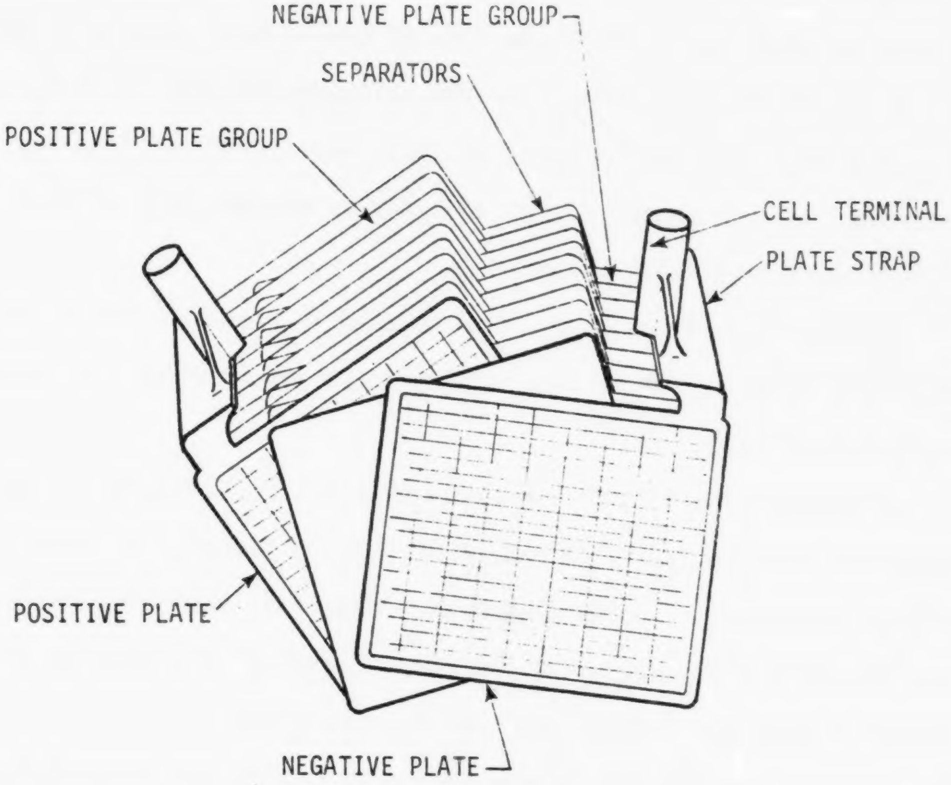

NEGATIVE PLATE GROUP
SEPARATORS
POSITIVE PLATE GROUP
CELL TERMINAL
PLATE STRAP
POSITIVE PLATE
NEGATIVE PLATE

Figure 3-4. Components of a battery element (shown pulled apart).

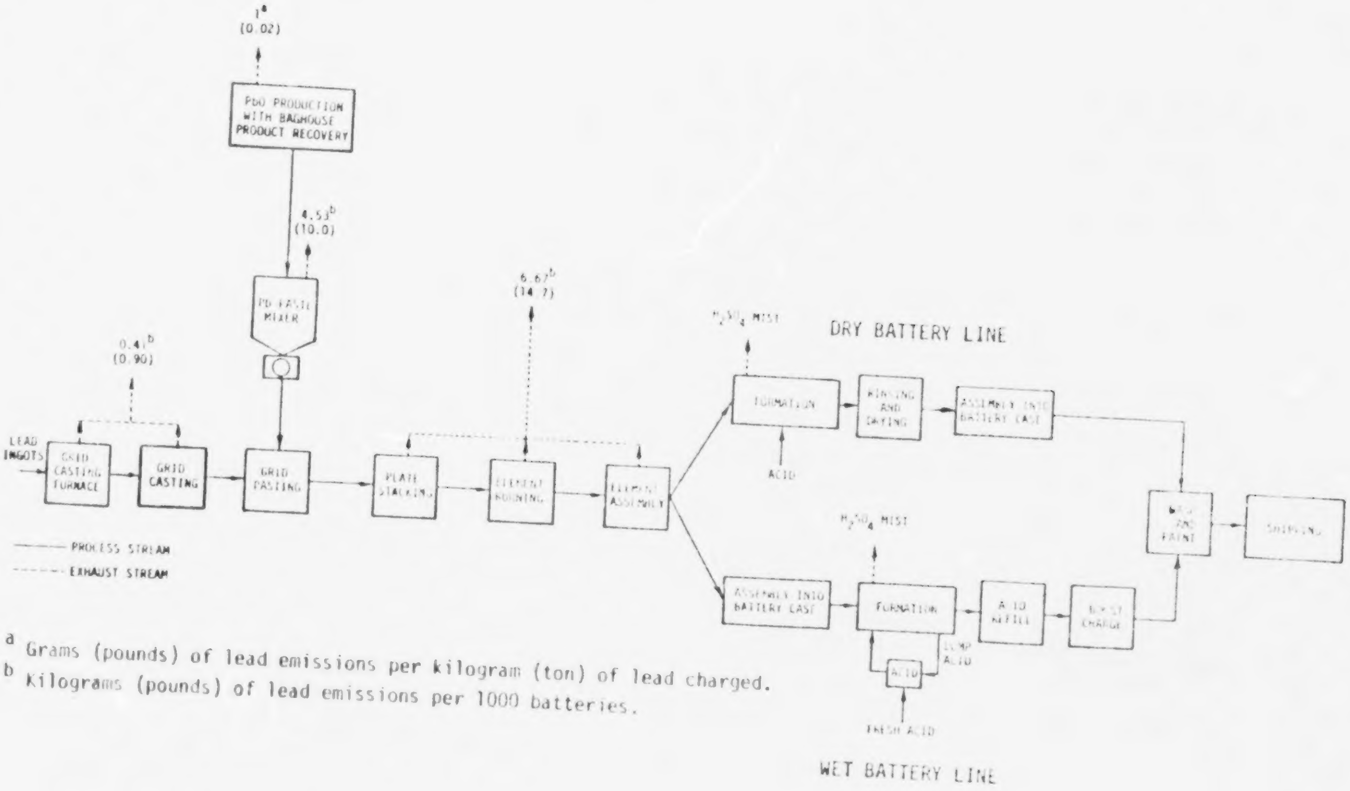
subtle differences in the lead alloy used in some of the plates (usually a substitution of calcium for some of the antimony) and generally they do consume so little water during normal operation that water addition is usually unnecessary during the life of the battery. However, manufacturing processes for these batteries, and the attendant emissions, are for all practical purposes identical to those for the conventional battery. Therefore, this document makes no distinction between this style of battery and conventional batteries.

Lead oxide (gray or black lead) is used in preparing the active materials. Many battery plants prepare the oxide in-house, and several processes are used.

A process flow diagram for the manufacture of lead-acid storage batteries is shown in Figure 3-5, with emission factors for uncontrolled process operations. As the figure indicates, this study encompasses only the battery manufacturing process and production of lead oxide (PbO); it does not include lead smelting operations.

Battery manufacturing begins with grid casting and paste mixing. The grids are generally cast in doublets (two grids per casting) from molten lead, to which 6 to 12 percent antimony has been added to provide hardness. These grids are coated with either positive or negative paste formed (a process discussed later), cut into two separate grids (a process called slitting) and then sent to be assembled into dry- or wet-type batteries.

Lead emission factors are shown in Figure 3-5, and estimated nationwide emissions are presented in Table 3-3. The lead emission factors for grid casting, paste mixing, and battery assembly are derived


1^a
(0.02)
PbO PRODUCTION WITH BAGHOUSE PRODUCT RECOVERY
4.53^b
(10.0)
Pb PASTE MIXER
0.41^b
(0.90)
6.67^b
(14.7)
LEAD INGOTS
GRID CASTING FURNACE
GRID CASTING
GRID PASTING
PLATE STACKING
ELEMENT BURNING
ELEMENT ASSEMBLY
H2SO4 MIST
DRY BATTERY LINE
FORMATION
ACID
RINSING AND DRYING
ASSEMBLY INTO BATTERY CASE
H2SO4 MIST
ASSEMBLY INTO BATTERY CASE
FORMATION
DUMP ACID
ACID
FRESH ACID
ACID REFILL
BOOST CHARGE
WASH AND PAINT
SHIPPING
WET BATTERY LINE
PROCESS STREAM
EXHAUST STREAM

[a] Grams (pounds) of lead emissions per kilogram (ton) of lead charged.

[b] Kilograms (pounds) of lead emissions per 1000 batteries.

Figure 3-5. Process flow diagram showing uncontrolled lead emission factors for lead-acid battery manufacture.

Reproduced from best available copy.

Table 3-3. NATIONWIDE EMISSIONS OF LEAD FROM THE MANUFACTURE OF LEAD-ACID STORAGE BATTERIES (1975)

Process	Throughput,[a] Gg	(ton) Pb	Estimated average control efficiency,[b] %	Uncontrolled emission factor, g/kg of lead throughput	(lb/ton)	Estimated actual emissions, Mg	(ton)
Lead oxide production	338	(373,000)	c	0.01	(0.02)	3.4	(3.7)
Grid casting	397	(327,000)	50	0.07	(0.139)[d]	10.3	(11.4)
Lead reclamation	6.2	(6,800)[e]	80	2.97	(5.9)	3.6	(4.0)
Paste mixing	338	(373,000)	90	0.86	(1.72)[d]	29.0	(32.0)
Three-process operation	635	(700,000)	90	0.56	(1.13)[d]	35.9	(39.6)
Total emissions for 1975						81.5	(90.0)

[a] Based on 1975 data.[29]

[b] Based on information obtained from battery manufacturers and control agencies throughout the study.

[c] Emission factor is based on controlled emissions; fabric filters are a part of the process.

[d] Based on test data in units of pounds of lead emissions per 1000 batteries and assumption of an average of 11.8 kg (26 lb) of lead per battery. Half is assumed to be in the castings and half in the paste.

[e] Estimated at 1 percent of total lead throughput.

from data obtained in tests performed as part of this study. Measurements of controlled and uncontrolled lead emissions were performed at selected plants manufacturing lead-acid batteries. (Reference to the individual plants in this report is by alphabetical code). Quantitative data on emissions of sulfuric acid mist from the formation process are not available.

Except for the lead oxide manufacturing facility, the particulate pollutant catch from the control systems, whether wet or dry, is reclaimed by a lead smelter. The particulate captured from the lead oxide manufacturing operation is used in the paste mixer.

3.2 GRID CASTING

Techniques for casting of grids vary with the alloy used, the type of molds, and mold preparation before casting. Molten lead alloy ingots are melted in a gas-fired lead pot at approximately 370°C (700°F). The furnace is often equipped with a hood to vent the fumes to a control device or to the atmosphere.

In some grid casting operations, melting pots are attached directly to the casting machines. The molten lead flows from the pots directly into the molds, where the grids are formed and then are ejected, trimmed, and stacked. Some facilities feed the molding machines from a central pot furnace, from which the molten lead is either pumped or fed by gravity. Pumping may cause air to be entrained in the molten lead, resulting in problems at the molding machines. Entrained air is not a problem with grid casting machines that are fed by gravity flow.

Emissions from the grid casting operations are generally low; even uncontrolled facilities can meet the most stringent state particulate regulations. Some manufacturers control emissions from this operation and others do not. Exhausts from the grid casting furnace are usually vented to the atmosphere to protect workers from the lead emissions. The areas around the casting machines are generally unvented.

Testing of the grid casting facility at Plant D (see Chapter 4, Section 4.1) indicated uncontrolled lead concentrations ranging from 0.9 to 5.9 mg/m^3 (0.00039 gr/dscf to 0.0026 gr/dscf, 0.049 to 0.34 lb/hr). At Plant D, the grid casting facility is operated for 24 hours each day and the production capacity is 4000 bpd. The measured lead emissions are equivalent to 408 g (0.9 lb) per 1000 batteries, or approximately 51.1 g/hr (0.113 lb/hr) for a typical 2000 bpd plant.

3.3 PASTE MIXING

The paste mixing operation, a batch-type process, is done with a muller, Day, or dough-type mixer. From 272 to 1361 kg (600 to 3000 lb) of lead oxide is added to the mixer; water and sulfuric acid are then added, and the mixture is blended to form a stiff paste. Because reactions of the process are exothermic, mixers are usually water-jacketed and air-cooled to prevent excessive temperature buildup which causes the paste to become stiff and difficult to apply to the grids. Approximately 1 weight percent of expander (generally a mixture of barium sulfate, carbon black, and organics) is added to batches of paste for negative plates.[30] Carbon black also provides color identification for the negative paste. A duct system vents the moisture-laden exhaust gases from the mixer. The duration of the mixing cycle depends on the type of mixer, ranging from 15 minutes to an hour. Typical formulas for positive and negative pastes are shown in Table 3-4.

TABLE 3-4. TYPICAL FORMULAS FOR POSITIVE AND NEGATIVE BATTERY PASTES[31]

Ingredient	Positive	Negative
Lead oxide, kg (lb)	272 (600)	272 (600)
Dynel fiber, kg (lb)	0.068 (0.15)	0.068 (0.15)
Expander, kg (lb)	None	1.90 (4.2)
Water, liter (quart)	23 (25)	26 (28)
H_2SO_4 (1.375-1.400 s.g.), liter (quart)	25 (26)	21 (22)

The major emissions from paste mixing occur during charging of the dry ingredients to the mixer. The high-emissions phase is about the first 10 minutes of a 60-minute mixing cycle. The emissions are in the form of lead oxide, with small amounts of other paste constituents such as Dynel, organics, and carbon black.

Source tests were performed at Plant D where the mixer was vented to a baghouse during materials charging and to a Roto-Clone during mixing. The baghouse also controlled the plate slitting operation, and the Roto-Clone also controlled the grid casting operation. Two tests run at the baghouse inlet during charging showed uncontrolled lead emissions of 115 and 34 mg/m^3 (0.050 and 0.015 gr/dscf, 10.4 lb Pb/hr and 2.99 lb Pb/hr). A single test to determine emissions from the slitting process indicated lead emissions of 43 mg/m^3 (3.88 lb/hr, 0.0188 gr/dscf). On the basis of these data, an emission factor for the total mixing operation (both charging and mixing) is estimated to be approximately 5.1 kg (11.2 lb) of lead per 1000 batteries, or 0.636 kg/hr (1.40 lb/hr) for a typical 2000 bpd plant.

3.4 THREE-PROCESS OPERATION - STACKING/BURNING/ASSEMBLY

After the plates are cured, they are normally sent to the three-process operation, which includes plate stacking, burning, and assembly of elements into the battery case. Some plants are equipped with an associated plate slitter, which cuts the double plates apart. At most plants the plates are parted by hand, after which they are stacked in an alternating positive and negative block formation with separators sandwiched between each plate to insulate the oppositely charged plates while permitting free ionic flow. These separators are made from materials such as wood, treated paper, plastic, or rubber. Although machines have been designed to stack the plates and separators automatically, hand stacking is common.

Leads (pronounced leeds) are welded to the tabs of each positive plate and each negative plate, fastening the assembly (element) together. This is the burning operation. An alternative to the welding or burning process is the cast-on-strap process, in which molten lead is poured around and between the plate tabs to form the connection. Then a positive and a negative terminal are welded to the element. The completed elements are then assembled into battery cases either before formation (wet batteries) or after formation (dry batteries). The difference between wet and dry batteries is explained in Section 3.5.

Most lead emissions are generated during plate stacking and burning or casting operations. Handling of plates between process steps also generates considerable lead emissions. Typically, operators straighten stacks by striking them against a grated surface. Upon impact, particles of paste become airborne. Work areas are generally vented to collect these particles and to protect the health of the workers.

Source tests at Plants B and D, with capacities of 4500 and 4000 bpd respectively, indicate that uncontrolled lead emissions from the three-process operation range from 20 to 54 mg/m^3 (0.0087 to 0.023 gr/dscf, 1.37 to 6.31 lb/hr) during full operation.* These tests indicate total three-process emissions, since testing of each process step in the facility is not feasible. On the basis of these data (presented completely in Chapter 4), an estimated emission factor for the three-process operation is 6.67 kg (14.7 lb) of lead per day for each 1000 bpd capacity, or 0.835 kg/hr (1.84 lb/hr) for a typical 2000 bpd plant.

3.5 FORMATION

During formation the inactive lead oxide-sulfate paste is chemically converted into an active electrode. Formation is essentially an oxidation-reduction reaction, in which the lead oxide in the positive plates is oxidized to lead peroxide and in the negative plates are reduced to metallic lead. This is accomplished by placing the unformed plates in a dilute (10-25 percent)[32] sulfuric acid solution and connecting the positive plates to the positive pole of a direct current (dc) source and the negative plates to the negative pole of the dc source.

During the formation process, hydrogen is released in the form of small bubbles, which carry sulfuric acid with them as they break through the surface of the solution and enter the atmosphere above the container. The process, therefore, is a source of sulfuric acid mist emissions.

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*Emissions data for the plate slitting operation at Plant D are included in the mixer emissions data since they are also vented to the baghouse that controls mixer exhaust.

Charging rate and temperature affecn the emissions of sulfuric acid mist, which generally increase with increasing temperature and rate of charge. Also, as the process nears the end of the formation cycle, the release of hydrogen bubbles increases. Emissions therefore increase with time.

3.5.1 Wet Formation Process

In manufacture of wet lead-acid batteries, the elements are assembled into the case before forming. It is common practice to place the cells in the battery case, place the lid on the battery, and add sulfuric acid. The plates are then formed within the battery case. After formation, the spent acid is dumped from the battery and new acid is added. With addition of a boost charge the unit is ready for use, requiring only decoration and manufacturer's markings.

Wet formation generally takes 1 to 4 days. Most plants use a 36- to 48-hour forming cycle. The charging rate is high during the first 24 to 36 hours and lower during the remaining 12 hours. The ampere rates depend on the battery size.

Emissions from wet formation processes are usually not controlled or ducted to a stack. Therefore, no data are available on quantitative emissions from the wet formation process. However, because of the slow charging rate, the fact that there is a lid or cap on the battery during formation, and the absence of a strong acid odor at wet formation processes, emissions from the process are believed to be small.

3.5.2 Dry Formation Process

The plates used in dry batteries are formed in several ways. Some plates are individually formed in tanks of sulfuric acid and then assembled.

Most, however, are assembled into elements before formation. The completed elements are then formed by placing the elements in large tanks of sulfuric acid and by then making an electrical connection to form the elements. Some manufacturers place the assembled elements directly in the battery case for formation. Thereafter, they remove the formed elements, dump the acid, rinse and dry the cases and elements, reassemble them, and ship the batteries dry. Dry formation typically last 16 hours, with the plates or elements loaded into tanks during the day shift, and formed during the evening and night shifts.

When forming batteries by the dry formation process, the acid mist can be controlled by the use of mist eliminators or scrubbers, but is commonly controlled by application of some sort of cover over the acid bath or receptable. The cover is usually of a surface foaming agent such as Alkonol or Dupanol.

Two dry formation processes have been sampled by EPA. The first test did not yield any valid results because the process was not operating properly (one of the three formation circuits was inoperative). Also, emissions from the control device were not detectable when EPA Reference Method 8 was used to collect emissions over a two hour sampling period. The second EPA test (Plant L) showed uncontrolled emissions toward the end of the cycle to average 66 mg/m^3 (0.029 gr/dscf, 0.70 lb/hr). This formation room formed 20,000 battery plates over a 16 hour period.

3.6 LEAD OXIDE PRODUCTION

The lead monoxide used in battery paste production is called lead oxide, black oxide, or battery oxide. The typical lead oxide contains approximately 70 percent PbO. The balance is free metallic lead. Lead oxide is produced either by the ball mill process or Barton process.

Each of the lead oxide manufacturing processes incorporates a baghouse for product recovery, since the value of the product is relatively high. Air-to-cloth ratios of these fabric filters generally are about 3/1, whether the filters are designed for product recovery or for emissions control. As a result, emissions from the lead oxide production facility are low.

3.6.1 Ball Mill Process

In the ball mill process oxidation is initiated by heat generated by tumbling pure lead pigs (ingots) in a mill. During the tumbling action the lead oxide that forms on the surface of the lead pigs and fine particles of unoxidized lead is broken off, forming a fine dust that is removed from the mill by a circulating air stream. The larger fraction is ground further in a hammermill. Air flow through the mill, the temperature of the charge, and the weight of the charge are controlled to product a specified ratio of lead oxide to finely divided metallic lead. The product is conveyed by totally enclosed screw conveyors to storage bins. Enough product is entrained in the mill exhaust gases to justify gas cleaning for product recovery. Fabric filtration is always a part of the process.

Tests performed at Plant B (shown in Appendix C) yielded average lead emissions of 0.475 g/kg (0.0095 lb/ton) of lead input. This plant operates two ball mill production lines equipped with fabric filters, one with an air-to-cloth ratio of 2/1 and the other with a ratio of 4/1. The filters are vented to a common stack.

3.6.2 Barton Process

In the Barton process, molten lead is fed to a circular pot and stirred rapidly. A series of baffles within the pot atomize the lead into extremely small droplets, which are then oxidized by an air stream directed over the surface of the molten lead. The resulting lead oxide is conveyed by the air stream to a fabric filter where the product is removed. The particle-size distribution, apparent density, and reactivity of the oxide are controlled by the temperature maintained in the pot and by the volume and speed of the air stream that carries away the reacted products. The larger particles are captured in a cyclone prior to the fabric filter and pulverized in a hammermill. They are then conveyed and collected by another fabric filter.

3.7 LEAD RECLAMATION

Lead reclamation is the process whereby relatively clean lead scrap is remelted and cast into pigs for use in the process. The melting is generally done in a pot-type furnace. Scrap, in the form of small parts or defective grids and plates, is charged to the furnace. This is often done sporadically, only when enough material is available for charging. Emissions from pot-type furnaces tend to be minimal. The lead is melted at relatively low temperatures and emissions usually are visible only when oily scrap or floor sweepings are charged. Source tests on Plant G's lead recovery process show uncontrolled lead emissions averaging 298 g/kg (5.9 lb/ton) of scrap input.

Many of the smaller plants have no lead reclamation facilities and send out the scrap for reclamation. No figures exist which indicate the amount of scrap which is reclaimed at battery plants nationwide. However, based on observations made during plant visits under this study, it would appear that approximately 5 percent of the lead that enters the industry's process stream winds up as scrap and that one-fifth of the battery manufacturing capacity, nationwide, recycles its lead in nonsmelting processes, i.e., a pot-type furnace. The net result is an estimated nonsmelting recycle rate of 1 percent of all lead charged to the battery manufacturing processes nationwide.

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4.0 EMISSION CONTROL TECHNIQUES

The lead-acid battery industry currently applies various particulate controls with efficiencies ranging from 50 to 99.8 percent.[1] An estimated 60 percent of these control devices used are baghouses with efficiencies ranging from 96 to 99.8 percent; the remaining 40 percent consists of venturi scrubbers, packed bed scrubbers, impingement and entrainment scrubbers, and cyclones with reported efficiencies ranging from 50 to 98 percent.[2]

Manufacturers often vent a number of processes to the same control device via a collection system of ducts and hoods. The control systems used at individual plants depend upon plant layout and economics of product recovery. Sections 4.1 through 4.5 describe emission control techniques applicable to facilities in the lead-acid battery industry. These sections also present the results of source tests performed for this study and other applicable data.

For this background study, emisions tests were conducted at four lead-acid battery plants (plants B, D, G, and L). Measurements of lead emissions from controlled sources were conducted according to the proposed EPA Reference Method 12---Determination of Inorganic Lead Emissions from Stationary Sources. EPA Reference Method 8, was used to measure emissions of sulfuric acid mist from formation processes.

In a prior study, lead emissions were tested at three plants (plants B, J, and K). The method used to measure lead emissions in these tests was similar to Method 12.

The results of emissions tests are presented in Appendix C and summarized in this chapter. The ranges of emission concentrations are depicted as data bars in several figures. These figures allow comparison of lead emission concentrations detected in the emission tests.

4.1 GRID CASTING MACHINES AND FURNACES

Emissions from grid casting furnaces are often uncontrolled, and many plants vent this facility to the surrounding work space rather than directly to the outside air. Some plants have used low-energy wet scrubbers to control these exhausts. There are no known applications of fabric filters on this facility.

Particle size data for particulates emitted from grid casters are presented in Figure 4-1.

4.1.1 Scrubbers

An impingement and entrainment scrubber, such as the type N Roto-Clone, is a common device for controlling grid casting emissions. These units are relatively small, with moderate power requirements (1245 Pa or 5 in. W.G. pressure drop) and low water requirements (makeup water typically less than 0.134 $1/m^3$ or 1 gal./1000 acf). Liquid-to-gas ratios generally range about 2.6 $1/m^3$ (20 gal./1000 acf) of exhaust. Collection efficiency is generally about 90 percent as indicated by EPA tests at Plant D.

Multiwash centrifugal or cascade scrubbers are also used. These units typically accomodate up to 1415 m^3/min (50,000 acfm) with water injection requirements as low as 0.4 $1/m^3$ (3 gal./1000 acf).

Frequently, grid casting machines and furnaces are vented along with other operations, such as small parts casting and lead reclamation, to a single low-energy scrubber.

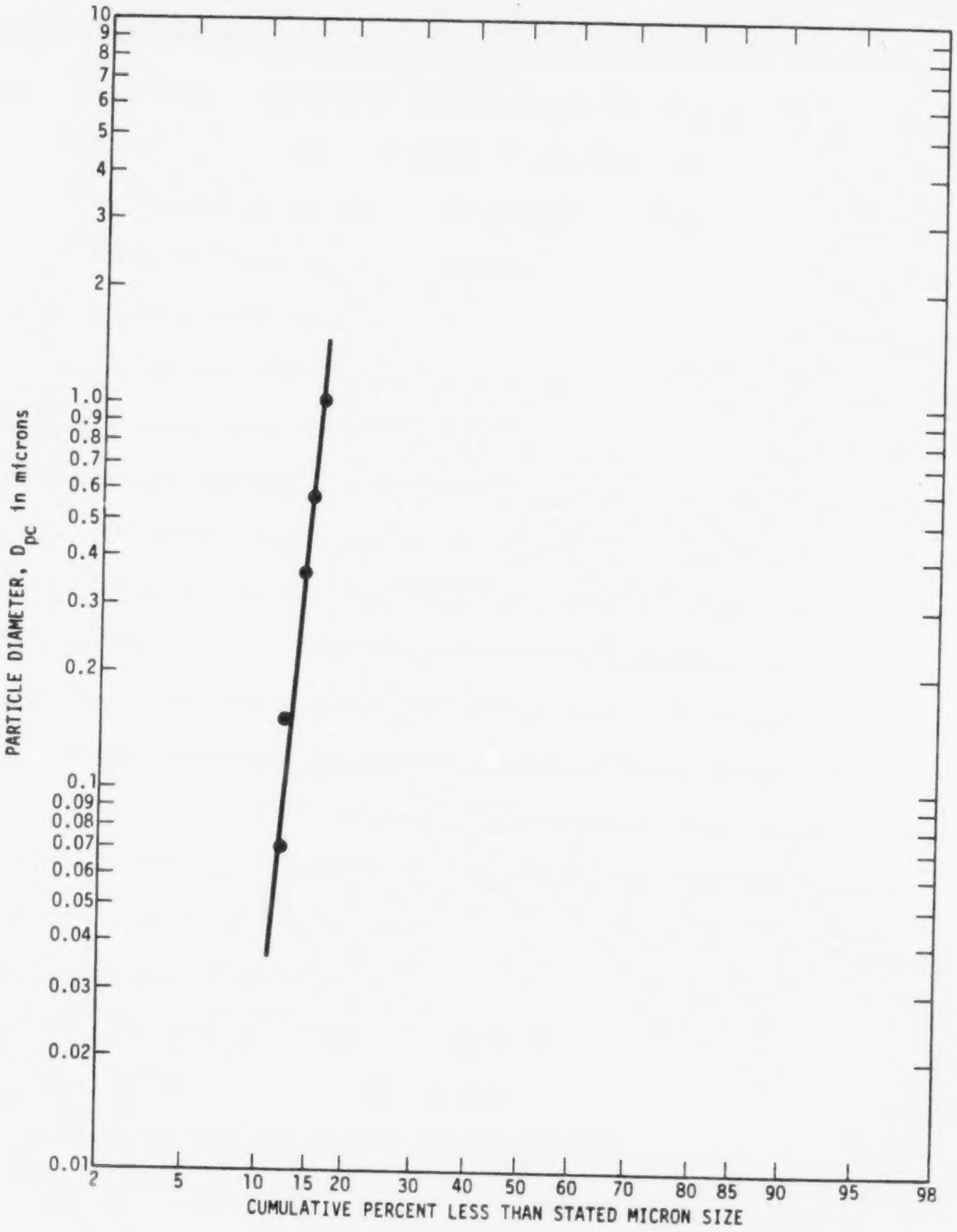


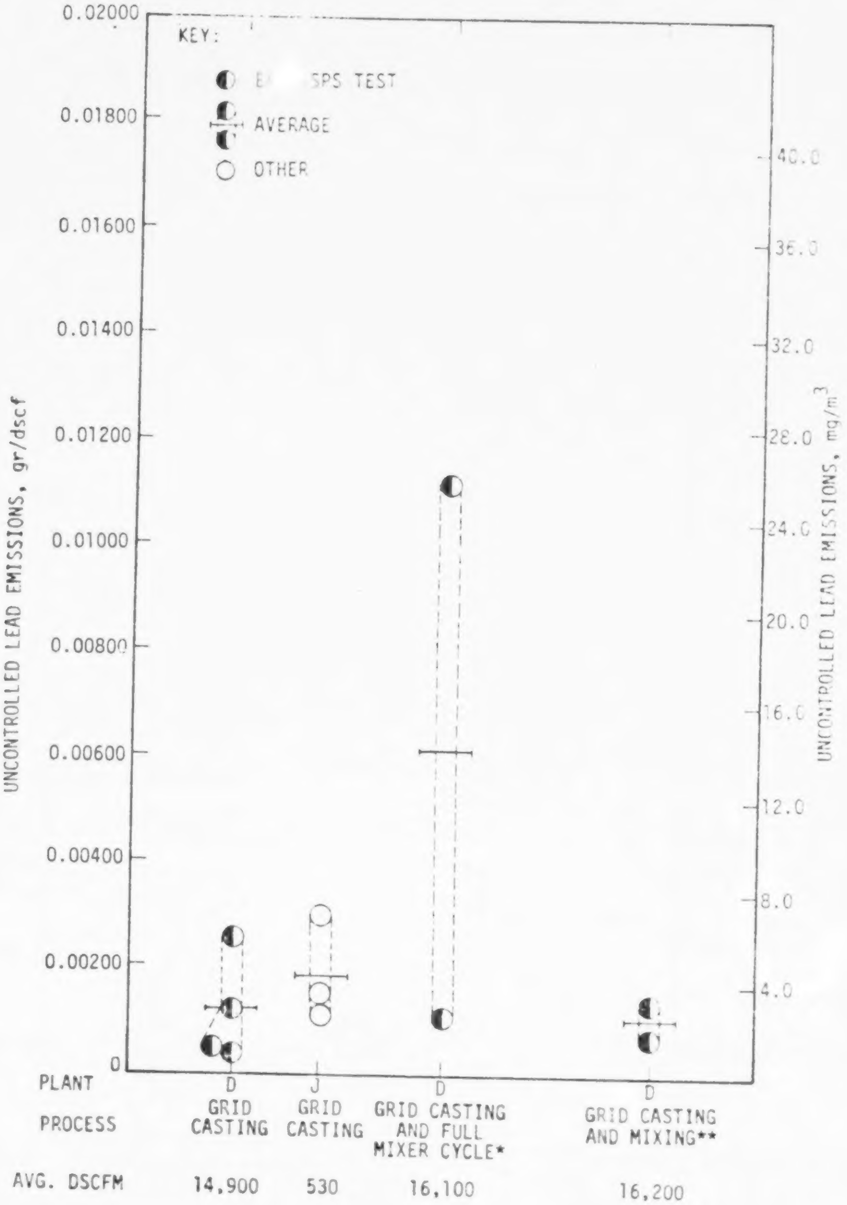
Figure 4-1. Particle size of particulate emissions from a grid casting operation.

4.1.1.1 Test Data--

Figures 4-2 and 4-3 indicate uncontrolled and controlled lead emissions, respectively, from a grid casting facility. All tests of grid casting emissions for this NSPS study were conducted at plant D. The grid casting facility and the paste mixing facility (during the mixing portion of its operating cycle only) were vented to an impingement and entrainment scrubber, having a pressure drop of 1245 Pa (5 in. W.G.), in a cycle shown graphically in Figure 4-4. Plant D has a production capacity of 4000 bpd but normally produces only 3200 bpd. Eight sets of concurrent source tests were run to determine uncontrolled and controlled emissions. Each set consisted of a test at the Roto-Clone inlet and one at the Roto-Clone outlet. Of these tests, four were run to determine uncontrolled grid casting emissions and one to determine controlled grid casting emissions. Other tests were run continuously through the entire mixing cycle (see Figure 4-4), and others were run only during those periods when both mixer emissions and grid casting emissions were vented to the Roto-Clone.

Uncontrolled lead emissions from grid casting ranged from 0.89 to 5.9 mg/m^3 (3.9 x 10^{-4} to 25.6 x 10^{-4} gr/dscf, 0.048 to 0.34 lb/hr), with an average of 2.65 mg/m^3 (11.6 x 10^{-4} gr/dscf, 0.15 lb/hr). The controlled emissions from grid casting were tested simultaneously with the test that yielded the highest uncontrolled lead concentration of grid casting lead emissions. In these concurrent tests, the Roto-Clone demonstrated a lead removal efficiency of 94 percent.

The process was operating normally during all tests. Although the small parts production facility is also ducted to the same Roto-Clone, no small parts were produced during the test periods. The small parts melting pot was fired at all times, however, and an unknown amount of

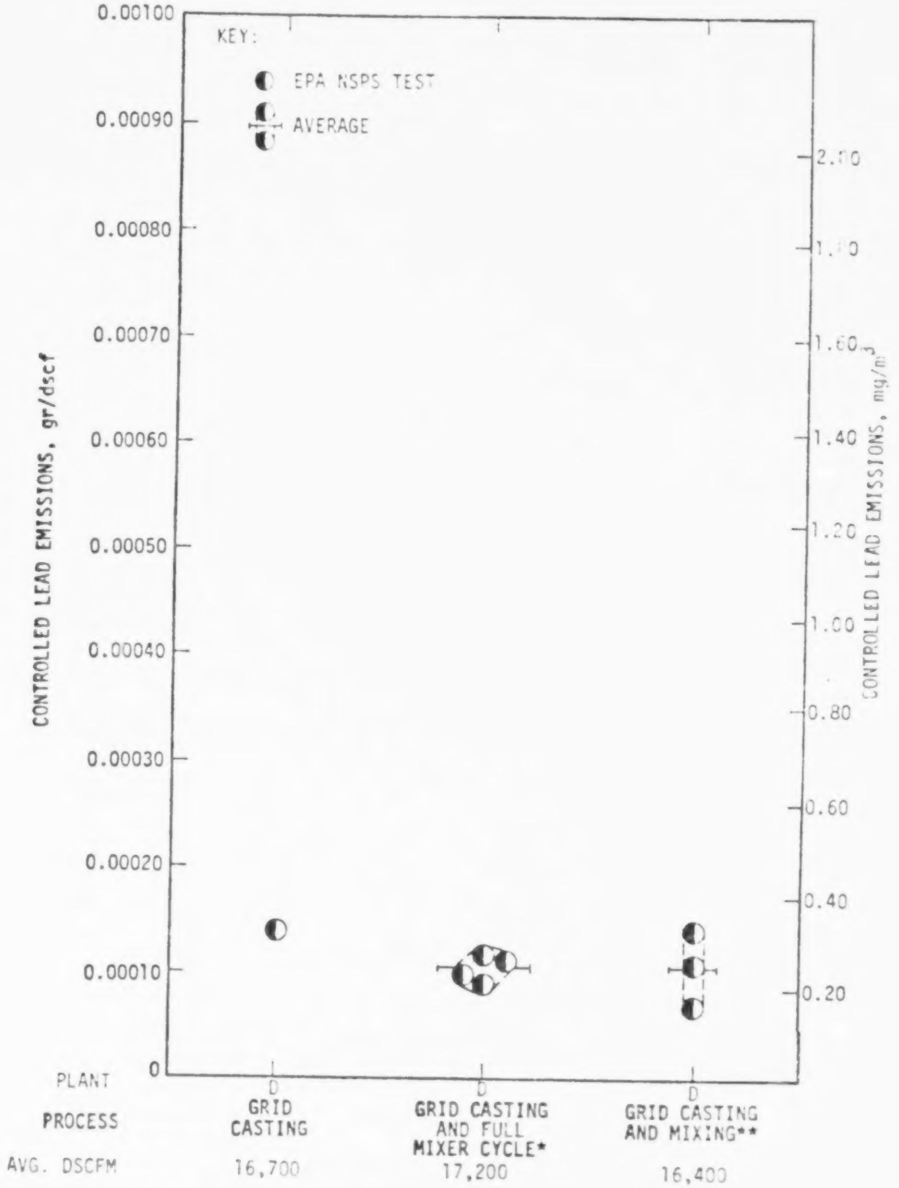


* Includes time during which mixer was charged.

** Excludes time during which mixer was charged.

Figure 4-2. Uncontrolled emissions from grid casting and combined grid casting and mixing.[a]

[a] At Plant D both grid casting and paste mixing exhausts were vented in common duct. See Figure 4-4.

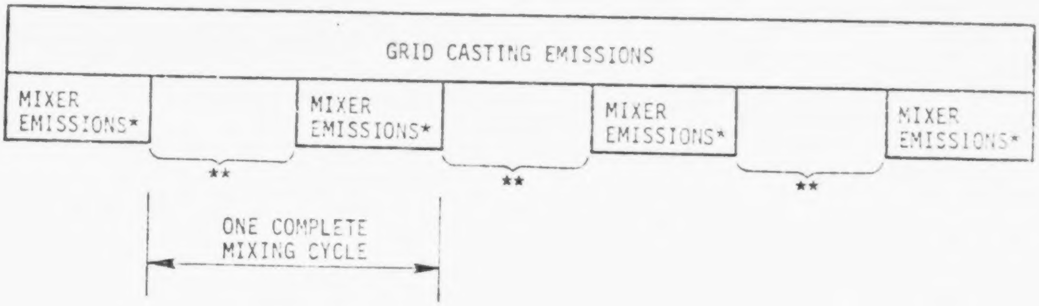


* Includes time during which mixer was charged.

** Excludes time during which mixer was charged.

Figure 4-3. Controlled emissions from grid casting and from combined grid casting and mixing.[a]

[a] At Plant D both grid casting and paste mixing exhausts were vented in a common duct. See Figure 4-4.


GRID CASTING EMISSIONS
MIXER EMISSIONS*
MIXER EMISSIONS*
MIXER EMISSIONS*
MIXER EMISSIONS*
**
**
**
ONE COMPLETE MIXING CYCLE

* Gases vented from mixer to Roto-Clone only during that portion of the cycle in which the ingredients are actually mixed.

** During that portion of the mixing cycle in which the ingredients are charged to the mixer, the mixer is vented to a baghouse---not to the Roto-Clone.

Figure 4-4. Graphic representation of emissions vented to Plant D Roto-Clone over a period of time.

lead emissions may be attributed to this melting pot. However when there are no parts being cast there is virtually no activity at this facility. Also the pot temperature is kept just below the melting point of lead thereby avoiding the formation of lead fumes. Therefore it is estimated that these emissions are negligible in relation to the grid casting emissions. Test results relative to mixer emissions (which occurred concurrent with the grid casting emissions) are discussed in Section 4.2.

In another study, grid casting emissions were tested at plant J. Uncontrolled lead emissions from this plant ranged from 2.70 to 7.05 mg/m^3 (11.8 to 30.8 gr/dscf) with an average value of 4.39 mg/m^3 (19.2 gr/dscf). The grid casting facility at this plant was not equipped with any emission control equipment.

4.1.2 Fabric Filters

As previously stated, there are no known applications of fabric filters on this facility. This is because of the potential blinding from mold release agents and the spark hazard from oil and powdered cork. The spark hazard has been minimized by using spark arresters in the control network in other metallurgical processes, and can be eliminated by simply recycling only clean scrap to the grid casting pots.

Another reason industry is reluctant to use fabric filters to control emissions from grid casting furnaces is the fear that mold release agents, most notably sodium silicate and acelylene soot, will cause fabric blinding and render the filter ineffective. Sodium silicate is commonly used in the industry to prevent the lead from sticking to the grid molds. It is applied by spraying an aqueous suspension of the material directly onto the molds.

The reason operators surmise that this will blind the fabric is its physical characteristics. It is a slimy substance which does not appear to dry readily. However, in practice, fabric blinding apparently does not occur. A major manufacturer which supplies sodium silicate to battery manufacturers successfully uses fabric filters to control emissions from his sodium silicate spray dryers, and reports no major operational or maintenance difficulties.[3]

Another technique used by some manufacturers to prevent lead from sticking to the molds is called acetylene burning. This is simply the use of an acetylene torch, without oxygen, to produce soot. This soot is blown onto the molds with the torch and produces an oily, carbonaceous film which acts as the mold release agent. This method is somewhat archaic and not used, or used very infrequently, by many major manufacturers. One major manufacturer uses this method only when manufacturing batteries for submarines.[4] Another manufacturer states that only one of his ten plants uses acetylene burning. When asked why only one of the ten plants uses the technique, the company's representative stated that this is simply the method they had gotten used to and they saw no reason to force a change.[5] EPA could not locate an installation which uses fabric filters to control acetylene soot. However, there are apparently several viable alternatives to acetylene burning at battery plants and this need not be a deterrent to the use of fabric filters. Based on the performance of fabric filters on the three-process operation (discussed in Section 4.3) an air-to-cloth ratio of about 6/1 should be adequate to control this process to 99 percent lead removal. No data are available for this specific application, however.

4.2 PASTE MIXER

Both baghouses and scrubbers are used to control paste mixing emissions. Some plants vent the mixer to a baghouse during the material charging phase and then to a wet collector during the final "wet" mixing phase. Most plants use only a scrubber.

Typically when two control devices are used, other operations are controlled by the same devices. For example, at Plant D, a baghouse controls the mixer during the charging period of the mixing cycle and it also controls the plate slitting machine at all times. The wet collector at Plant D is a Type N Roto-Clone that controls the paste mixer during the mixing period of the cycle and also controls the grid and small parts casting machines and furnaces at all times. Use of the Roto-Clone during the mixing cycle prevents possible plugging of the bags by the moist exhaust. The exhaust stream is transferred from one control device to the other via an automatically operated damper located at the mixer hood.

Particle size for particulate emissions from the paste mixer at Plant D are presented in Figure 4-5.

4.2.1 Scrubbers

An impingement entrainment scrubber such as the Type N Roto-Clone is frequently used to control mixing operations. These units are relatively small, (in the range of 30 to 300 m^3/min [1,000 to 10,000 acfm]) with a pressure drop of approximately 1245 Pa (5 in. W.G.). Makeup water is generally less than 0.134 l/m^3 (1 gal./1000 acf) and liquid-to-gas ratios generally are about 2.6 l/m^3 (20 gal./1000 acf) of exhaust. Most of the water loss is due to evaporation; about 20 percent results from recirculation tank blowdown. Collection efficiency is approximately 90 percent, as indicated below.

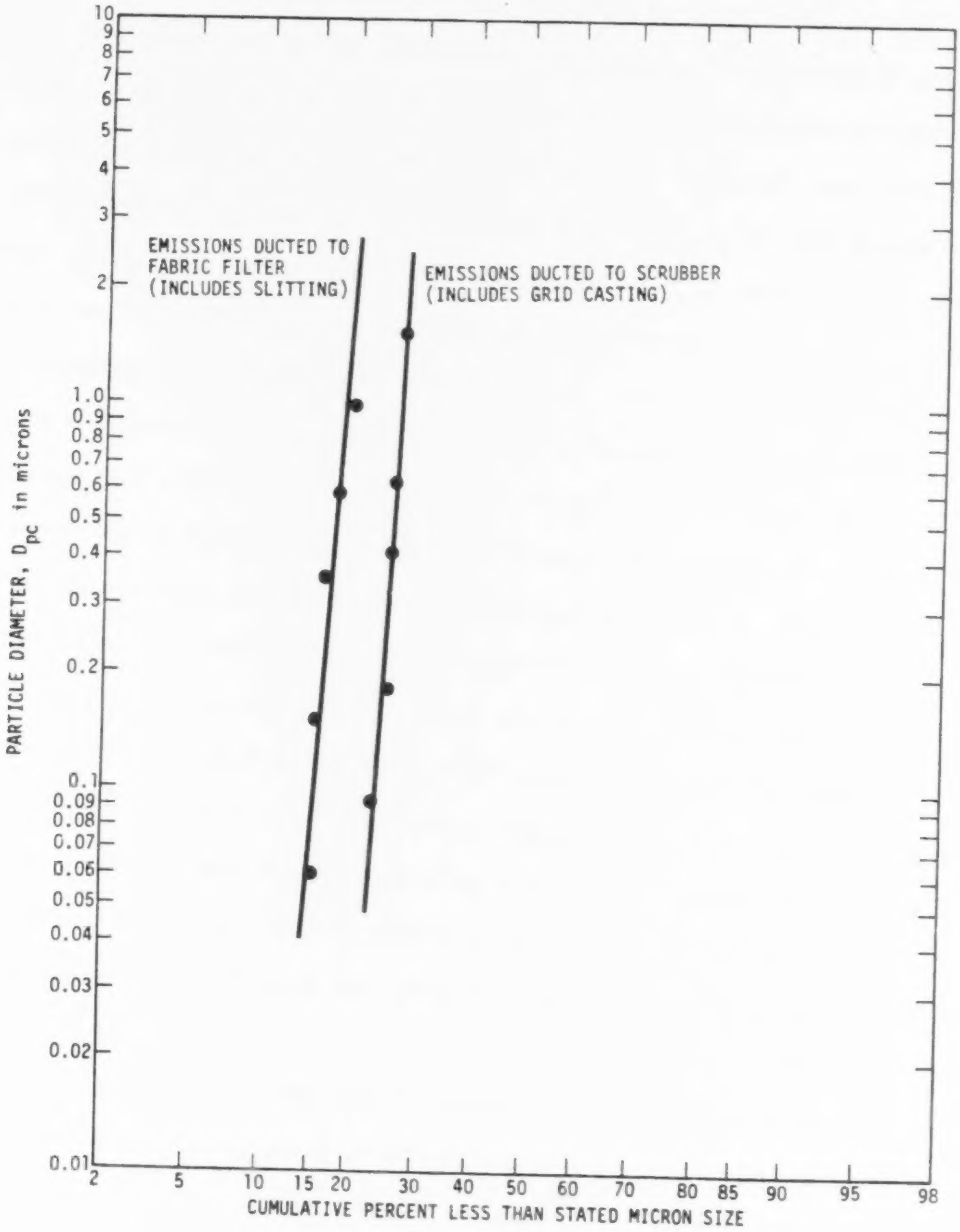


Figure 4-5. Particle size of particulate emissions from a paste mixer.

4.2.1.1 Test Data--

All paste mixing source tests under this program were run at Plant D. Source tests were run at the inlet and outlet of the Roto-Clone, having a pressure drop of 1245 Pa (5 in. W.G.), both continuously (including the time when the mixer exhausts were ducted to the baghouse) and during the mixing portion of the cycle only. Two inlet samples and four outlet samples were taken during full mixing cycles; two inlet samples and three outlet samples were taken during mixing only. Figures 4-2 and 4-3 show the results of these tests. During full mixing cycles (the continuous tests), uncontrolled lead emissions at the inlet were 2.4 and 25.4 mg/m^3 (10.6 x 10^{-4} and 111 x 10^{-4} gr/dscf, 0.153 and 1.47 lb/hr); the controlled lead emissions ranged from 0.21 to 0.27 mg/m^3 (0.9 to 1.2 x 10^{-4} gr/dscf, 0.013 to 0.017 lb/hr). The two sets of tests run concurrently indicated Roto-Clone removal efficiencies for lead of 98.8 and 89.5 percent. Uncontrolled lead emissions measured during the mixing portion of the cycle only (keep in mind that all Roto-Clone data include emissions from the grid casting operation) were 1.6 and 3.2 mg/m^3 (7.0 x 10^{-4} and 13.9 x 10^{-4} gr/dscf, 0.09 and 0.20 lb/hr). Controlled emissions ranged from 0.16 to 0.32 mg/m^3 (0.7 x 10^{-4} to 1.4 to 10^{-4} gr/dscf, 0.0096 to 0.021 lb/hr). Roto-Clone efficiencies during the two sets of tests run concurrently were 89.6 and 89.7 percent.

As the figures indicate, results of the tests at the Roto-Clone show no clear difference in lead emissions in relation to the operating mode of the processes vented to the control device. Results of the source tests for controlled lead emissions indicate that the Roto-Clone can reduce lead concentrations to less than 0.34 mg/m^3 (1.5 x 10^{-4} gr/dscf) (approximately 0.02 lb/hr at this plant). Furthermore, efficiency calculations indicate that a properly maintained wet collector can control approximately 90 percent of the lead emissions from grid casting and paste mixing.

In a previous study, paste mixing emissions were tested at plant J. At this plant, the entire mixing cycle is controlled by a Schneible multistage impingement scrubber with a pressure drop of 500 Pa (2 in. W.G.). The lead removal efficiency of this scrubber was 86 percent.[6] The inlet and outlet grain loadings of lead averaged 77.3 and 10.8 mg/m^3 (338 x 10^{-4} and 47.0 x 10^{-4} gr/dscf), respectively. The measured exhaust rate was approximately 5.4 m^3/min (190 dscfm).

While the efficiencies of the Cascade scrubber and Roto-Clone (86 and 90 percent respectively) at Plants J and D are about the same, comparisons are difficult regarding the relative efficiencies of the two devices. The lead particulate concentration of the inlet stream at Plant J is an order of magnitude higher than the concentration at Plant D and it is generally accepted that the more concentrated the exhaust stream, the more efficient the control device.

4.2.2 Fabric Filters

Fabric filters with air-to-cloth ratios ranging from 4/1 to 8/1 are used to control particulate and lead emissions from the charging phase of paste mixing. The bags are typically made from orlon felt, polyester, cotton sateen, dacron, or wool. Pressure drops across the bags are 249 to 1494 Pa (1 to 6 inches W.G.).

There appear to be no technological reasons why fabric filters cannot be used to control emissions from the entire mixing cycle. This is currently being done at at least one facility.[7] However, the fabric filter at this facility does not have provisions for preventing the paste mixer gas from falling below its dew point in the baghouse. Consequently, this installation occasionally experiences a high pressure drop across the fabric filter, apparently because of the moisture which combines with the particulate to form a mud cake which blinds the bags.

Condensation of moisture in fabric filters is a potential problem which has been overcome by other industries.[8] The solution usually involves insulation of the baghouse and all ductwork leading to it, and often requires the installation of a small auxilliary heater to keep the gas temperature above its dew point. This auxilliary heat is sometimes needed only during startup or shutdown of the facility. To provide a margin of safety, it is recommended that the gas temperature be maintained 50-75° F above its dew point.[9]

4.2.2.1 Test Data--

The mixer at Plant D is vented to a baghouse during the dry materials charging portion of the mixing cycle and while the mixer is idle. This baghouse has no provisions for preventing condensation of moisture. Therefore, as explained in Section 4.2, the gases are diverted to a scrubber during the portion of the cycle when moisture is evolved. The same baghouse continuously controls the slitting operation. The slitter divides the pasted grids into two plates. Slitting is not common to all lead-acid battery manufacturers and is considered an affected facility under "other lead-emitting operations." Many plants break the pasted grids into two plates after curing.

Source tests were run at the inlet and outlet of the Plant D baghouse. One test was run during slitting only, one was run during the full mixing cycle (including the times when the mixer was vented to the scrubber), and two were run during mixer charging only. Figures 4-6 and 4-7 show the results of these tests.

Prior to the tests, lead emissions from the slitting operations were expected to be negligible when compared with the emissions from

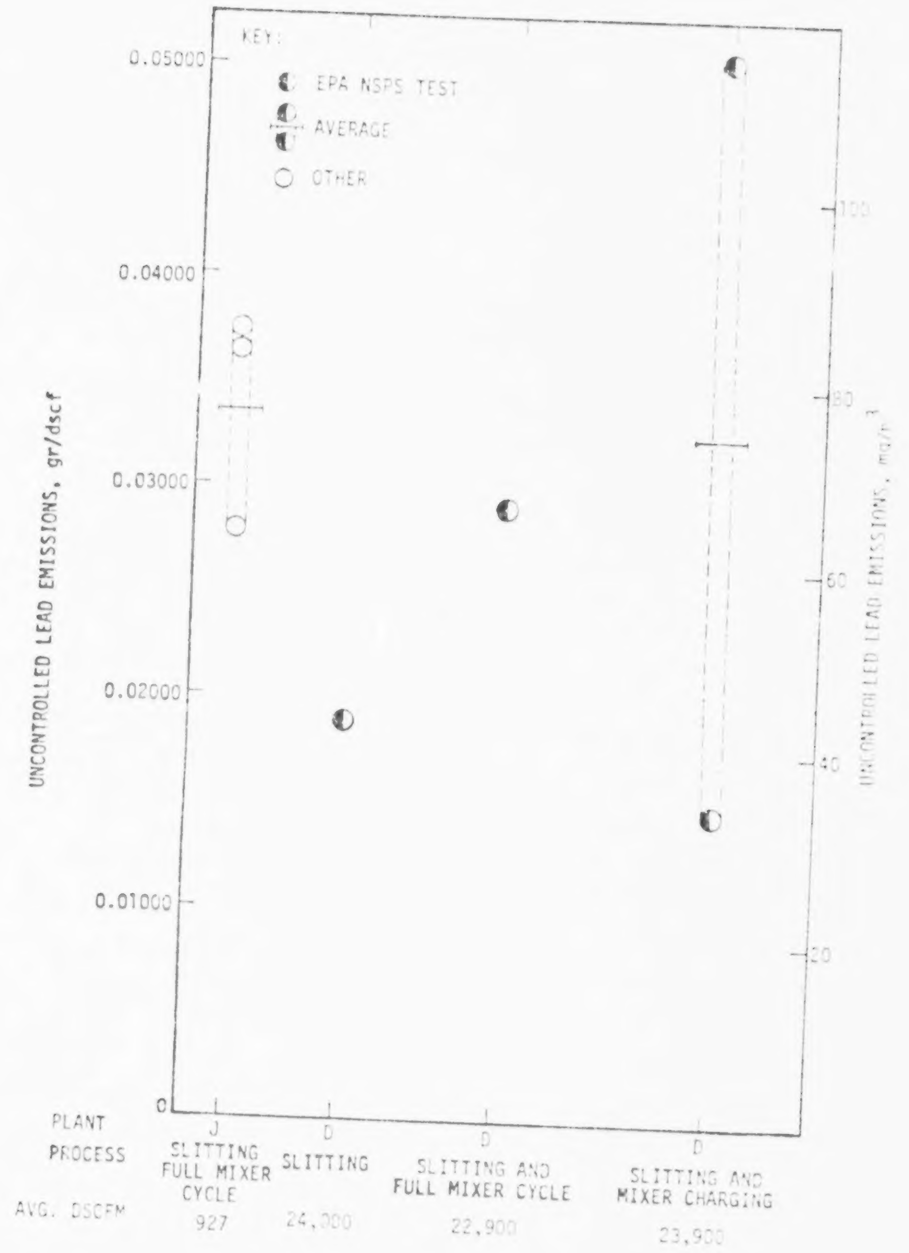


Figure 4-6. Uncontrolled paste mixing and slitting emissions.[a]

[a] At Plant D both grid casting and paste mixing exhausts were vented in a common duct. See Figure 4-4. The slitting station exhausts were also vented to the same common duct.

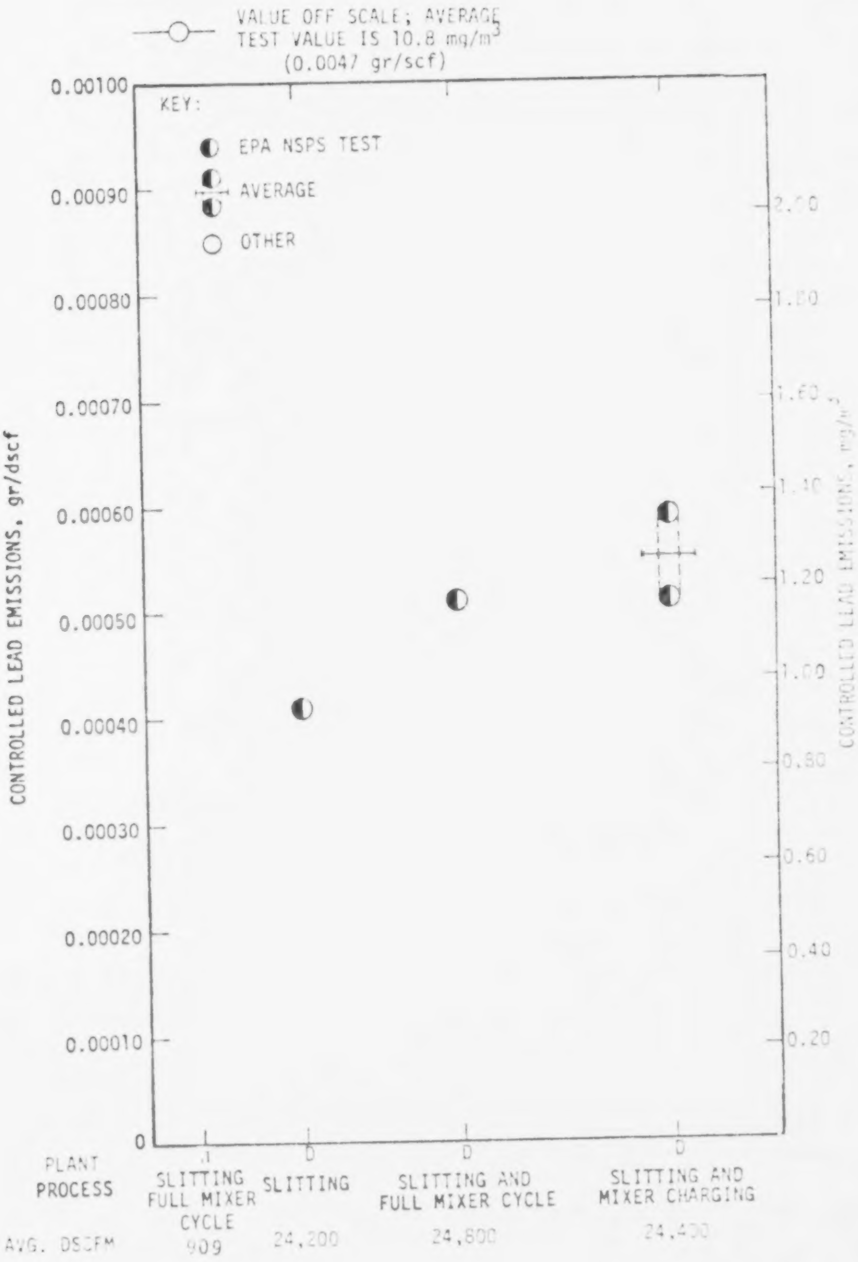


Figure 4-7. Controlled paste mixing and slitting emissions.[a]

[a] At Plant D both grid casting and paste mixing exhausts were vented in a common duct. See Figure 4-4. The slitting station exhausts were also vented to the same common duct.

materials charging.[10] However, the source test conducted during slitting indicated inlet and outlet concentrations of 43.0 and 0.94 mg/m^3 (188 x 10^{-4} and 4.1 x 10^{-4} gr/dscf, 3.88 and 0.060 lb/hr), respectively. Concentrations during the full mix cycle were 66.6 and 1.2 mg/m^3 (291 x 10^{-4} and 5.1 x 10^{-4} gr/dscf, 5.72 and 0.108 lb/hr) at inlet and outlet, respectively. Two tests were run at the baghouse during materials charging and slitting only. One indicated concentrations of 116 and 1.2 mg/m^3 (505 x 10^{-4} and 5.1 x 10^{-4} gr/dscf, 10.4 and 0.106 lb/hr) at the inlet and outlet, respectively; the other test indicated inlet and outlet concentrations of 33.6 and 1.4 mg/m^3 (147 x 10^{-4} and 5.9 x 10^{-4} gr/dscf, 2.99 and 0.124 lb/hr), respectively.

Because of the small number of tests for each operating mode and the variability of the data, it is impractical to estimate mixer emissions by difference; that is, by subtracting the emissions attributable to slitting. However, the source tests do indicate that a baghouse controlling emissions from the materials charging and slitting operations can reduce lead concentrations to less than 1.37 mg/m^3 (6.0 x 10^{-4} gr/dscf) (approximately 0.125 lb/hr at Plant D). Calculations of removal efficiency also show that a properly maintained baghouse controlling these processes can reduce lead emissions by at least 98 percent.

4.3 THREE-PROCESS OPERATION (STACKING, BURNING AND ASSEMBLY)

Well-controlled lead-acid battery plants use fabric filters or scrubbers to control the three-process operation. Most plants vent the stacking, burning, and assembly operations into a common duct prior to cleaning the gases. Other plants clean exhausts from paste mixing and the three-process operation with a common system.

Particle size data for particulate emissions from the three-process operations at Plants B and D are presented in Figures 4-8 and 4-9.

4.3.1 Fabric Filters

Based on plants surveyed by EPA, the industry typically uses shaker-type fabric filters having air-to-cloth ratios of 6/1 to 7/1 to control three-process emissions. Hood design is very important because of the large number of emission points (stacking, burning, and assembly usually are performed at several stations).

4.3.1.1 Test Data--

The three-process operation facilities at Plants B and D were tested, with results as shown in Figures 4-10 and 4-11. Plant capacities are 4500 and 4000 bpd at B and D, respectively. During the tests, Plant B averaged 1660 batteries during 7 hours of production and Plant D averaged 1600 batteries during approximately 7 hours of production. Air-to-cloth ratios of the baghouses are 6.5/1 and 3.3/1 at Plants B and D, respectively. Three-process production is essentially the same at both plants.

Three pairs of tests at the baghouse inlet and outlet were performed at Plant B, which processes both wet and dry batteries in the three-process operation. The plates and separators at this plant are stacked at four manual stacking stations and two automated stations. The stacks are processed on two automatic element assembly units (cast-on-strap [or COS] machines) and on a proprietary system. Lead concentrations at the baghouse inlet were 30.0, 33.6, and 19.9 mg/m^3 (131 x 10^{-4}, 147 x 10^{-4}, and 87 x 10^{-4} gr/dscf, 1.99, 2.30, and 1.37 lb/hr) in the three tests. Outlet concentrations were 0.44, 0.07, and 0.04 mg/m^3 (1.94 x 10^{-4},

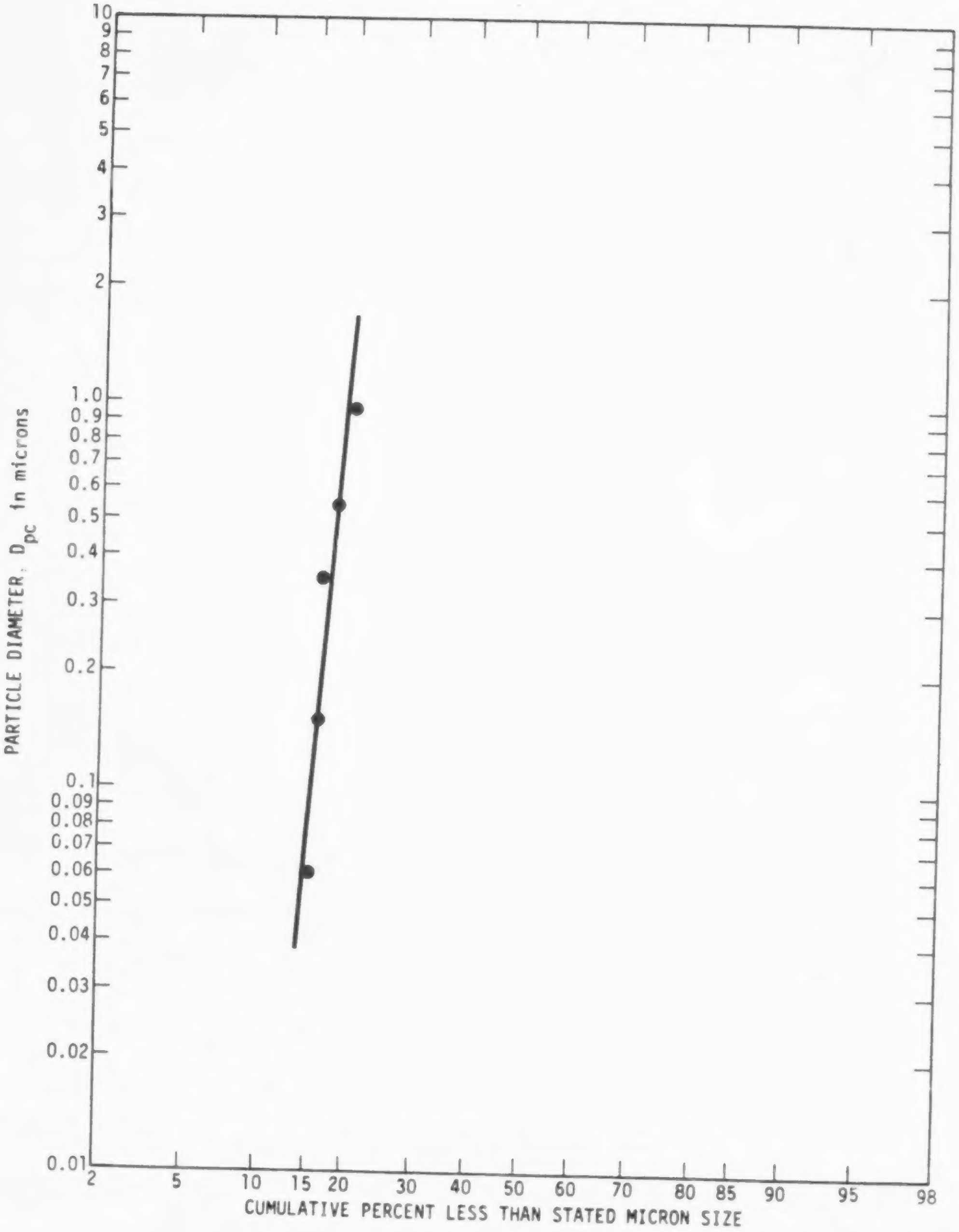


Figure 4-8. Particle size of particulate emissions from a three-process operation.

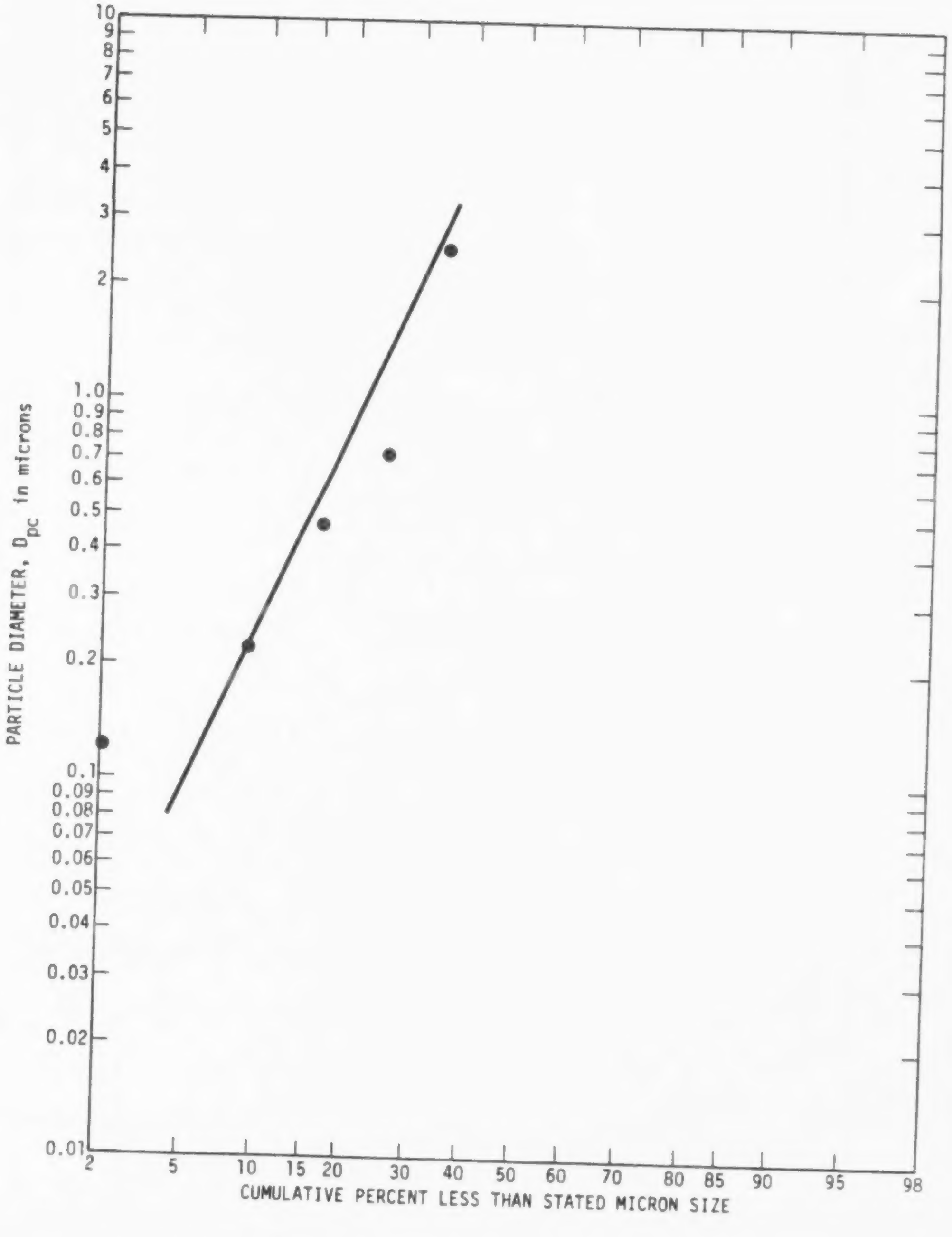
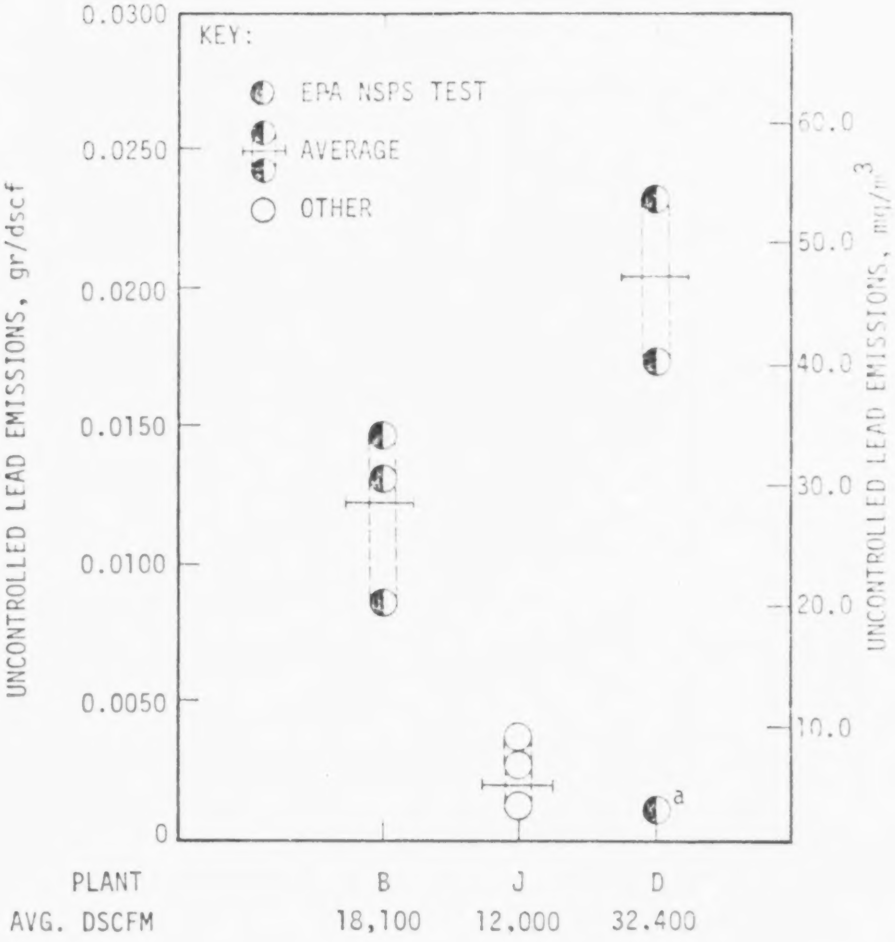
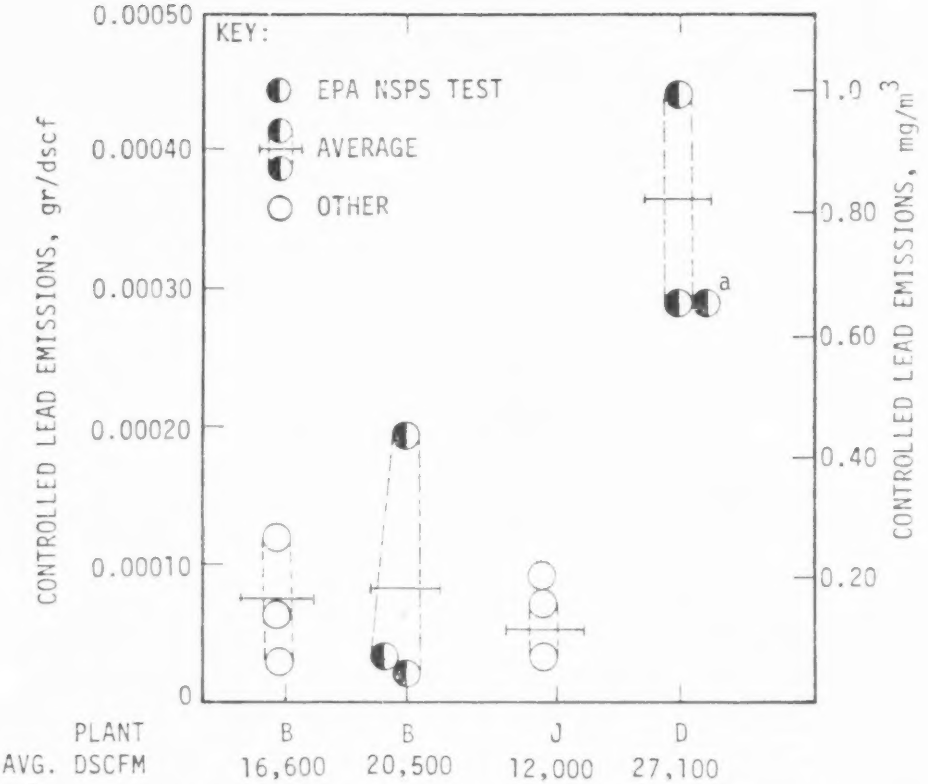


Figure 4-9. Particle size of particulate emissions from a three-process operation.



[a] Sample point not included in average because of process equipment downtime during test.

Figure 4-10. Uncontrolled three-process-operation lead emissions.



[a] Sample point not included in average because of process equipment downtime during test.

Figure 4-11. Controlled three-process-operation lead emissions.

0.32 x 10^{-4}, and 0.19 x 10^{-4} gr/dscf, 0.0347, 0.0056, and 0.0033 lb/hr). The average lead concentrations at the baghouse inlet and outlet, respectively, were 27.9 and 0.19 mg/m^3 (122 x 10^{-4} and 0.82 x 10^{-4} gr/dscf, 1.87 and 0.015 lb/hr), giving an average control efficiency of 99.2 percent.

Three pairs of tests were also performed at the inlet and outlet of baghouses controlling three-process operations at Plant D. The three-process facility at Plant D consists of three production lines. Two of the lines are equipped with mechanical stackers and COS machines. The other line has a mechanical stacker, and the elements are joined by manually burning the leads, (pronounced leeds). Baghouse inlet concentrations were 40.0, 53.3, and 2.4 mg/m^3 (175 x 10^{-4}, 233 x 10^{-4}, and 10.6 x 10^{-6} gr/dscf; 5.09, 6.31, and 0.29 lb/hr). The outlet concentrations were 0.55, 1.0, and 0.66 mg/m^3 (2.4 x 10^{-4}, 4.4 x 10^{-4}, and 2.9 x 10^{-4} gr/dscf; 0.071, 0.093, and 0.071 lb/hr). The markedly lower concentrations at the inlet in the third test apparently are attributable to process down-time during the test. The outlet lead emissions were not significantly affected. The average inlet and outlet concentrations, respectively, over the two sets of tests were 46.7 and 0.82 mg/m^3 (204 x 10^{-4} and 3.6 x 10^{-4} gr/dscf; 5.7 and 0.082 lb/hr), giving an average control efficiency of 98.6 percent.

In tests performed earlier at Plants B and J the controlled lead emissions averaged 0.15 and 0.13 mg/m^3 (0.67 x 10^{-4} and 0.56 x 10^{-4} gr/dscf), respectively. Uncontrolled lead emissions at Plant J averaged 4.3 mg/m^3 (18.7 x 10^{-4} gr/dscf), indicating a baghouse efficiency of 97 percent.

The results show that a baghouse can control the three-process facility to levels less than 1.15 mg/m^3 (5.0×10^{-4} gr/dscf) with lead removal efficiencies greater than 97 percent.

4.3.2 Scrubbers

Impingement type scrubbers are sometimes used to control three-process emissions. These scrubbers typically operate with a pressure drop of approximately 1245 Pa (5 inches W.G.) with lead collection efficiencies ranging about 90 percent as indicated by tests at Plant D (grid casting and paste mixing). Makeup water requirement for this type of scrubber is usually less than 0.134 l/m^3 (1 gal./1000 acf) at a liquid-to-gas ratio of 2.6 l/m^3 (20 gal./1000 acf) of exhaust.

4.4 LEAD OXIDE PRODUCTION

Lead oxide in the form of fine particulate matter is manufactured in a ball mill or a Barton pot. Most lead oxide facilities of both types use mechanical collectors followed by a baghouse to capture the lead oxide production after it leaves the ball mill or Barton pot. Most of the product is separated in a settling chamber or cyclone, and the baghouse serves to increase the product collection efficiency. The baghouse is considered as both process equipment and air pollution control equipment. Therefore, for economic reasons, wet collection devices such as high-energy scrubbers or Roto-Clones are not used.

4.4.1 Fabric Filters

Based upon EPA survey data air-to-cloth ratios of baghouses for collection of lead oxide range from 2/1 to 4/1. A low ratio is needed to prevent blow-through of the collected material from one side of the bag to the other.

4.4.1.1 Test Data--

The lead oxide production facility at Plant B was tested, with results as shown in Figure 4-12. Lead oxide is produced by two ball mills, each followed by two baghouses which provide particulate control and also collect the product. One ball mill is controlled by two baghouses in parallel having air-to-cloth ratios of 2/1 and pressure drops of 249 to 498 Pa (1 to 2 inches W.G.); the other ball mill is controlled by two baghouses in parallel having air-to-cloth ratios of 4/1 and pressure drops of about 1494 Pa (6 inches W.G.). Exhausts from all four baghouses are combined and released to the atmosphere through a single stack. The normal feed rate to each ball mill is 189 grams of lead per second (1500 pounds per hour), input for the two mills totaling 378 g/sec (3000 lb/hr); the feed rate can be increased as required to 314 grams per second (2500 pounds per hour) to give a total rate of 624 g/sec (5000 lb/hr). Throughout the tests, the lead feed rate was 189 g/sec (1500 lb/hr) through each ball mill, totaling 378 g/sec (3000 lb/hr).

Three tests were run at the common outlet of the four baghouses associated with lead oxide production. No tests were performed at the baghouse inlets. The lead concentrations in the three tests were 1.1, 2.3, and 1.1 mg/m^3 (4.9 x 10^{-4}, 9.9 x 10^{-4}, and 4.9 x 10^{-4} gr/dscf; 0.010, 0.022, and 0.011 lb/hr), giving an average lead concentration of 1.5 mg/m^3 (6.6 x 10^{-4} gr/dscf, 0.014 lb/hr). These values are equivalent to emissions of 3.17, 6.35, and 3.17 grams (0.007, 0.014, and 0.007 pounds) of lead per ton of lead input to the process. Tests at Plant B in 1974 indicated average lead emissions of 0.39 mg/m^3 (1.7 x 10^{-4} gr/dscf, 0.0026 lb per ton of lead input).[11]

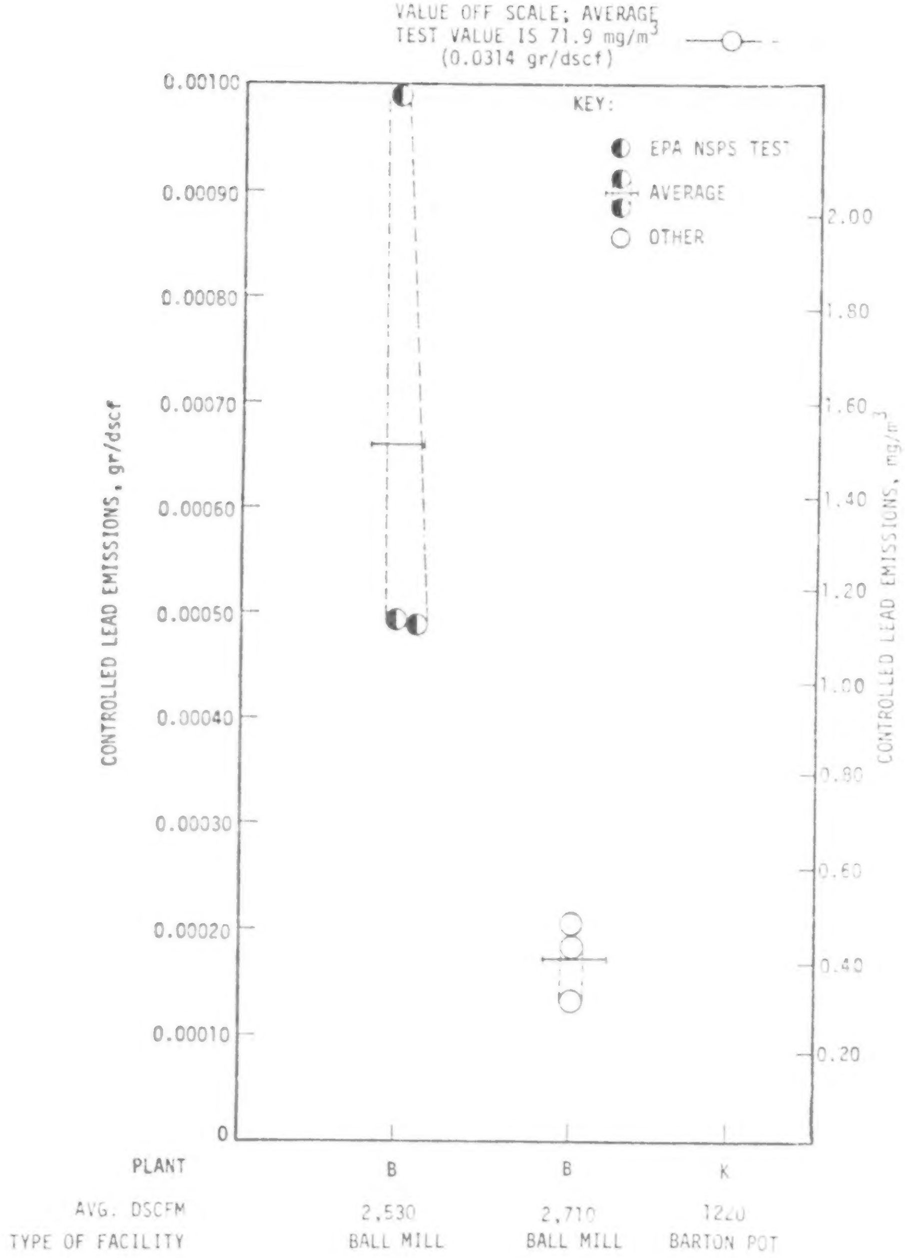


Figure 4-12. Emissions from lead oxide production using a baghouse for product recovery.

The test results show that operation of baghouses in a control recovery system can reduce lead emissions from a ball mill lead oxide production facility to less than 1.1 mg/m^3 (5.0 x 10^{-4} gr/dscf).

The only data available on lead emissions from a baghouse-controlled Barton Process are from tests performed in 1973 at a lead oxide manufacturing plant.[12] These data show emissions at the baghouse outlet averaging 71.9 mg/m^3 (314 x 10^{-4} gr/dscf or 0.45 lb/ton of lead input). This level is significantly higher than those obtained in tests of ball mill emissions. However, the test report did not specify air-to-cloth ratio, or fabric type so no conclusions can be drawn regarding Barton Process versus ball mill lead oxide production emissions. No other test data on Barton pot emissions are available.

4.5 LEAD RECLAMATION

The exhaust gas stream from the lead reclamation process is similar to the grid casting and small parts casting exhaust gases in that both are characterized by high temperatures and lead fumes. Since these gas streams are similar in character it is not uncommon to vent these processes to a common control device.

Particle size data for particulates emitted from a lead reclamation furnace are presented in Figure 4-13.

4.5.1 Scrubbers

Lead reclamation furnaces are generally controlled with low-energy wet scrubbers. Low-energy multistage or Roto-Clone-type wet collectors are used most frequently, with pressure drops less than 2 kPa (8 inches W.G.) and liquid-to-gas ratios of 0.4 to 0.7 l/m^3 (3 to 5 gal./1000 acf).

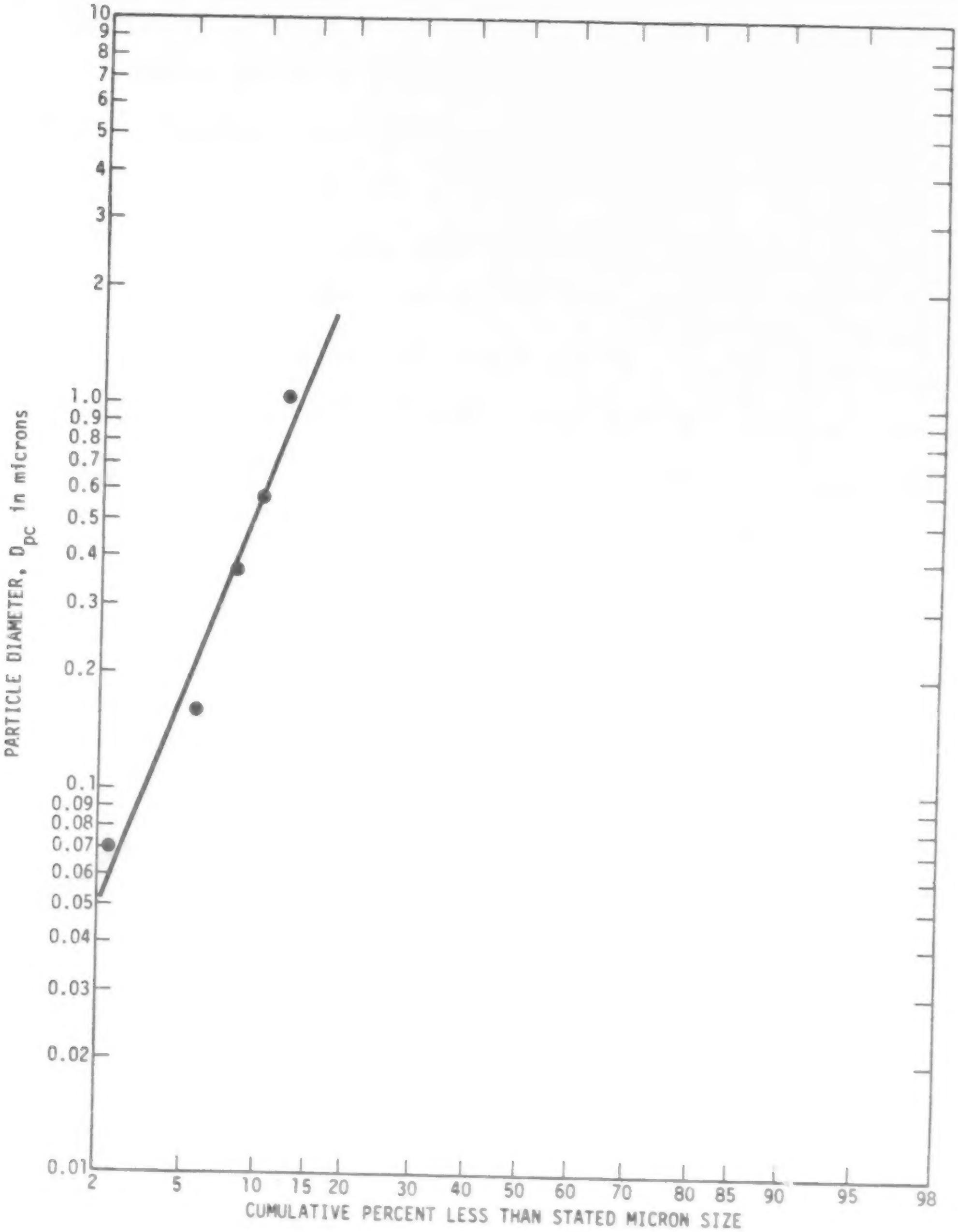


Figure 4-13. Particle size of particulate emissions from a lead reclaim furnace.

The lead reclamation facility at Plant G is controlled with a cascade scrubber. Tests of uncontrolled and controlled lead emissions gave the results shown in Figures 4-14 and 4-15, respectively. Charges of scrap lead during three tests were 431, 404, and 508 kg (950, 890, and 1120 lb). The liquid-to-gas ratio ranges from 0.53 to 0.70 l/m^3 (4 to 5 gal./1000 acf) of exhaust at a pressure drop of 498 to 747 Pa (2 to 3 in. W.G.). This scrubber also controls the small parts casting facility, which was not operating during the tests.

Three tests for lead were run at both the inlet and outlet of the cascade scrubber. Lead concentrations at the inlets were 175, 214, and 293 mg/m^3 (765×10^{-4}, 937×10^{-4}, and 1280×10^{-4} gr/dscf; 2.10, 2.69, and 3.72 lb/hr). Concentrations at the outlet were 2.2, 4.3, and 3.9 mg/m^3 (9.4×10^{-4}, 19×10^{-4}, and 17×10^{-4} gr/dscf; 0.028, 0.059, 0.050 lb/hr). Average inlet and outlet concentrations were 229 and 3.4 mg/m^3 (1000×10^{-4} and 15×10^{-4} gr/dscf, 2.8 and 0.046 lb/hr), respectively. These values indicate an average control efficiency of 98.3 percent.

The test results demonstrate that a low-energy scrubber can reduce emissions from lead reduction to average less than 3.7 mg/m^3 (16×10^{-4} gr/dscf, 0.05 lb/hr) at a plant with a facility of this size.

4.5.2 Fabric Filters

A survey of plants performed by EPA indicates that fabric filters are not used on lead reclamation facilities at lead-acid battery plants. They are, however, applied to hot exhaust streams in other industries. Examples are baghouse applications for control of emissions from electric arc furnaces and sinter plant windboxes in the iron and steel industry. Tests of baghouses at Plants B and D indicate that a lead collection

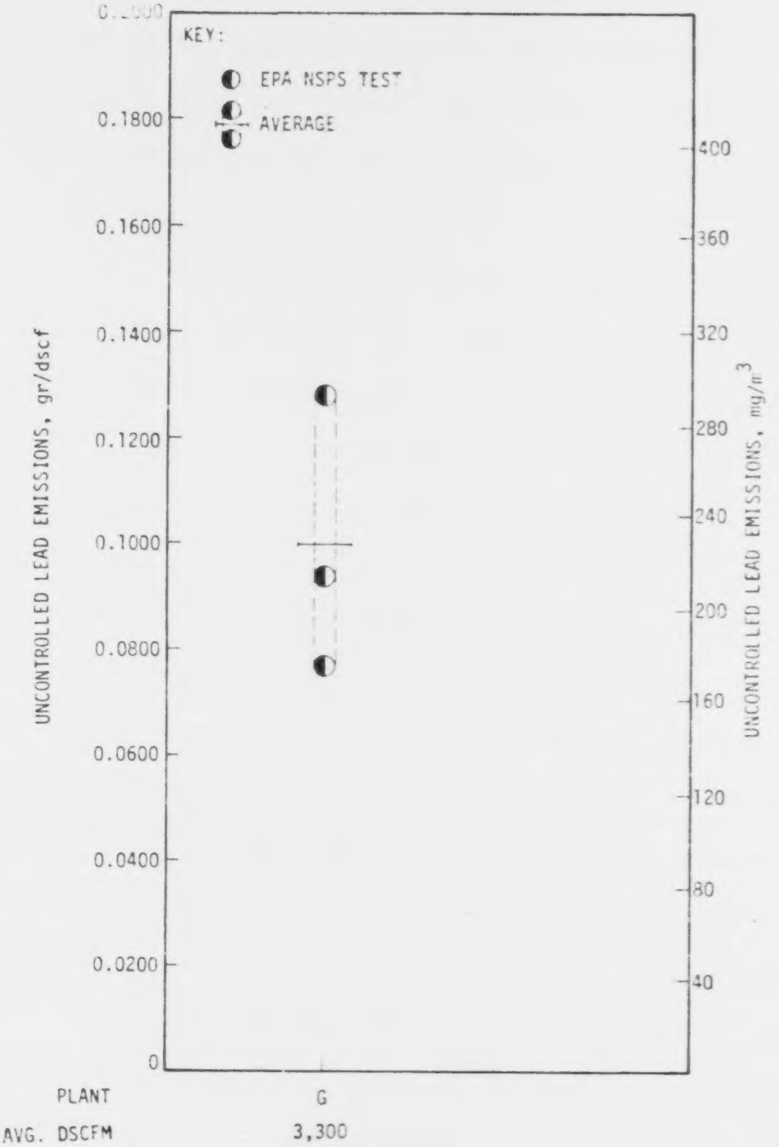


Figure 4-14. Uncontrolled lead emissions exhaust to a cascade scrubber controlling lead reclaim emissions.

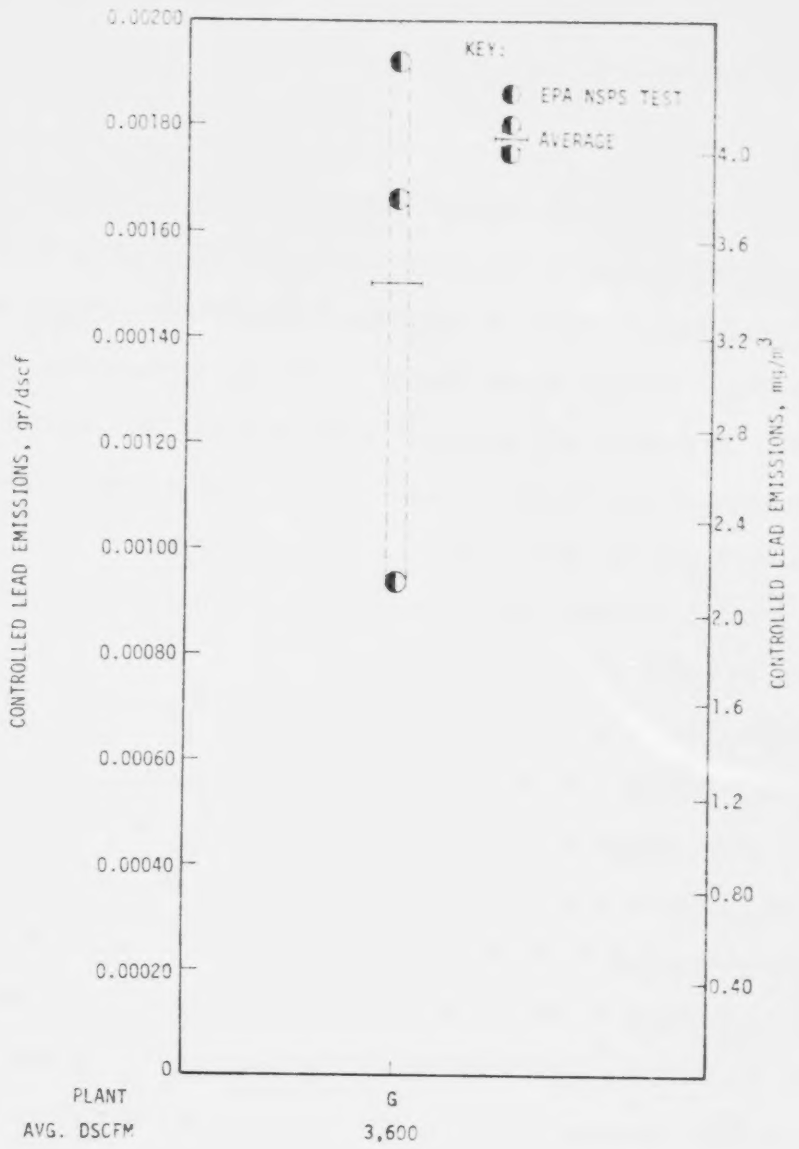


Figure 4-15. Controlled lead emissions from a cascade scrubber controlling lead reclaim emissions.

efficiency in excess of 98 percent can be achieved. These devices controlled exhaust gases from the three-process operation stations and had air-to-cloth ratios of 6/1 and 3/1 respectively.

4.6 FORMATION

As explained in Chapter 3, formation processes are divided into two categories, those which form in the battery case and those which form in open tanks. Formation processes do not emit lead, but are a source of sulfuric acid mist. Battery plates formed inside the battery case are formed slowly (1 to 4 days) and are usually destined for wet-charged batteries. Battery plates formed in open tanks are formed more rapidly (usually 16 hours) and are used to make dry-charged batteries. The type of emissions control for these processes depends on whether or not the formation area is enclosed.

Very little data on emissions from formation processes are available from any source. However, based on observations during plant inspections, the processes which appear to generate much higher emissions are those which form the plates in open vats. This is also evidenced by the fact that most companies which form the battery plates inside the assembled battery have no ductwork to remove emissions from the work area, and there appears to be no concern about industrial hygiene from either plant or government personnel. Plants which do duct the emissions from the work area (those which form in an open vat) have a more acute emission problem. These plants typically use either foam, scrubbers, mist eliminators, or combinations of these control techniques to minimize emissions to the production area and the outside air. Following are emission control practices used for formation processes.

4.6.1 Control Techniques

4.6.1.1 Good Work Practice--

When the formation area is not vented to a control device, such as when the battery is formed after complete assembly, the operator should form the batteries slowly and keep every battery filler cap on the battery at all times during the formation period. This minimizes emissions to the work area, and hence to the atmosphere. One large battery manufacturing company leaves the top of the battery case off during the assembly process and does not install the top until after formation is complete. During formation, a dummy, reuseable cover is placed on top of the batteries being formed. This helps to reduce emissions since much of the sulfuric acid mist impinges on the slave cover and condenses back into the battery.[13]

4.6.1.2 Water Sprays--

Many plants which form in the battery case (wet formation) spray the batteries with water during the formation process. The spray may absorb some sulfuric acid mist but is primarily used to keep the temperature of the batteries lower than it would normally be since, as experienced in Chapter 3, sulfuric acid mist emissions increase proportionally with acid temperature during formation.[14]

4.6.1.3 Ceramic-Disk Caps--

One manufacturer who forms the batteries while they are completely assembled in the case has a patented battery filler cap which has a ceramic disk on the inside of the cap. The only escape for the gas is through the cap, and this manufacturer claims that the disk absorbs hydrogen (which is a carrier for the sulfuric acid mist), thus virtually eliminating sulfuric acid mist emissions generated during formation. The acid is dumped from the battery after formation and the batteries are centrifuged to remove any remaining acid. After centrifuging, the "wet" batteries are filled with fresh acid and the "dry" batteries are shipped as is.[15]

4.6.1.4 Foam Covers--

Some companies which form the batteries in open tanks (dry formation) cover the tanks with a layer of foam. Two foaming agents typically used are Alkonol and Dupanol. These foaming agents control sulfuric acid mist by collecting the mist particles from the surface of the sulfuric acid solution before they can escape into the formation room. Three formation processes using foam were surveyed by EPA. Subjective measurements of the mist cloud above forming tanks and the characteristic acid odor in the forming room suggested a decrease in acid mist emissions when foam is used. Emission measurements at one plant (Plant L) did not confirm a reduction in emissions (see Section 4.6.2 and Appendix C).

4.6.1.5 Scrubbers--

The only companies which use scrubbers are those which form the batteries in open vats (dry formation). The scrubbers used by these companies are typically low energy type scrubbers, such as the Heil fume washer (a scrubber and mist eliminator), and several non-commercial designs. Plants which use scrubbers either enclose the formation tanks and duct the emissions to the scrubber, or they form the battery in a room which can be closed off. The emissions in the room are then ducted to the scrubber.

4.6.1.6 Mist Eliminators--

Some companies which form their batteries in open vats use mist eliminators rather than scrubbers. A popular brand used by this industry is the Tri-Mer scrubber. This mist eliminator catches the mist particles as they go through a fan separator followed by a packed tower. The packing is then periodically washed (called flushing) on a schedule ranging from once per day to two or three times per shift.

4.6.2 Test Data

Two open vat-type (dry) formation processes have been sampled by EPA. The first test did not yield any valid results because the process was not operating properly (one of three formation circuits was inoperative). Also, emissions from the control device were not detectable when EPA Reference Method 8 was used to collect emissions over a two-hour sampling period. Uncontrolled emissions were not sampled at this plant.

The second formation process (Plant L) was sampled during four separate sixteen-hour cycles. The emission control on formation at this plant consisted of the use of foam in combination with a scrubber/mist eliminator. Samples were taken at the inlet and outlet of the scrubber/mist eliminator during three formation cycles when foam was in use and one cycle when foam was not applied. Because emissions from the formation process increase towards the end of the sixteen-hour cycle, only samples taken during the last five hours of each cycle were analyzed for average emissions. These results are shown in Figures 4-16 and 4-17. Acid mist emissions without the use of foam were 65 mg/m^3 (0.028 gr/dscf, .66 lb/hr) before the scrubber and 1.6 mg/m^3 (0.0007 gr/dscf, 0.02 lb/hr) after the scrubber/mist eliminator. With the use of foam, emissions averaged 66 mg/m^3 (0.029 gr/dscf, 0.70 lb/hr) before the scrubber and

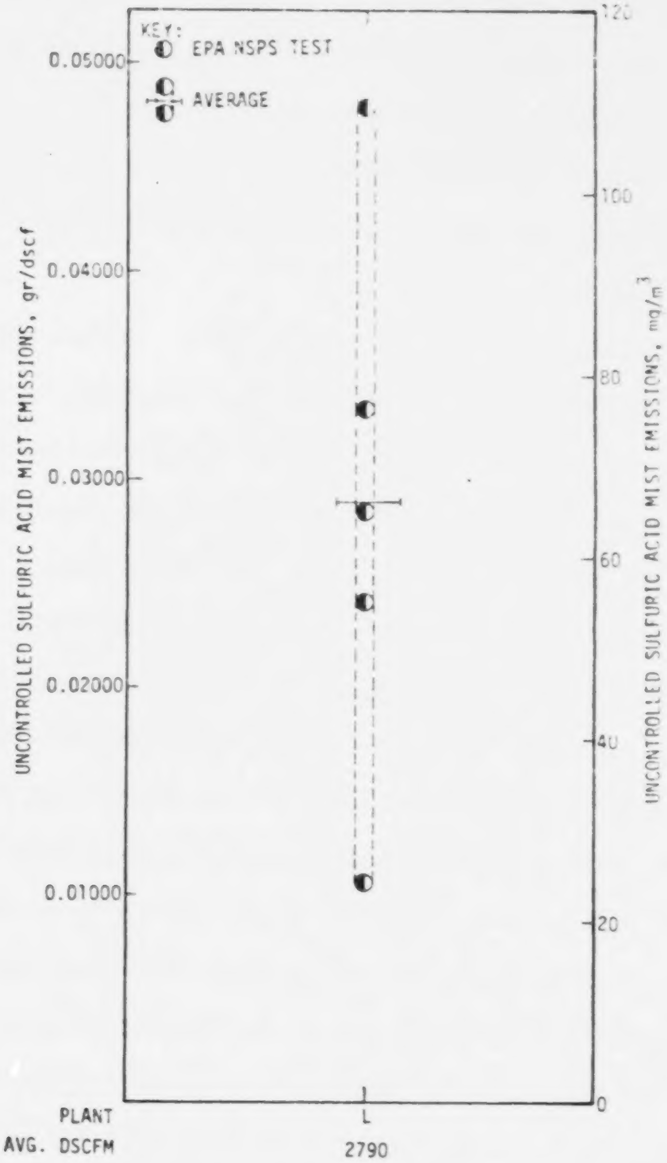


Figure 4-16. Uncontrolled formation emissions.

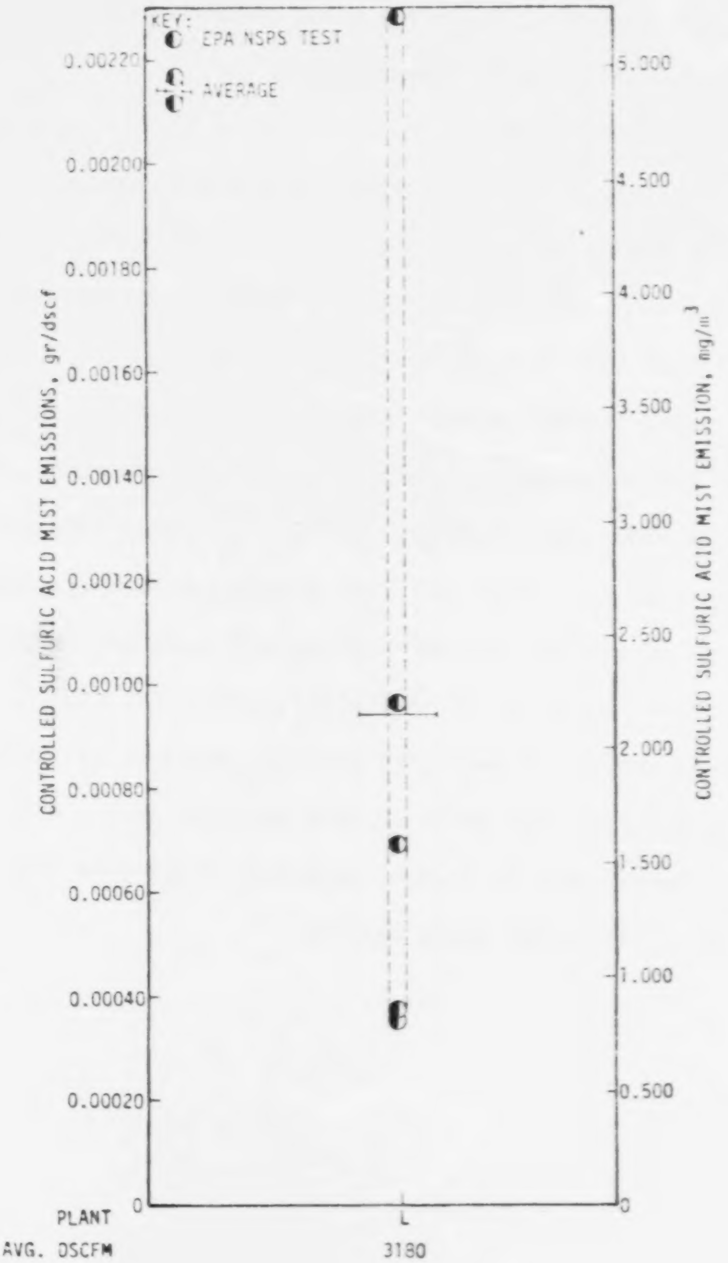


Figure 4-17. Controlled formation emissions.

$2.3\ mg/m^3$ (0.001 gr/dscf, 0.03 lb/hr) after control. Additional detail on these tests is presented in Appendix C.

4.7 CONTROL PERFORMANCE SUMMARY

Figures 4-18 and 4-19 respectively, show average uncontrolled and controlled lead emissions from all processes tested during the EPA test program. Table 4-1 summarizes control equipment parameters during these tests. Details of the tests are presented in Appendix C.

The lead-acid storage battery industry generally uses low energy scrubbers to control production processes which evolve gases containing moisture or possible spark hazards. EPA has concluded that fabric filters can be used to control all lead emitting processes, provided that necessary precautions are taken to prevent moisture condensation and sparks. This conclusion is partially based on the similarity of emission characteristics (especially particle size) of all battery manufacturing processes for which we have emission data. Also, fabric filters are commonly used to control emissions from other industries having similar moisture and spark hazards.

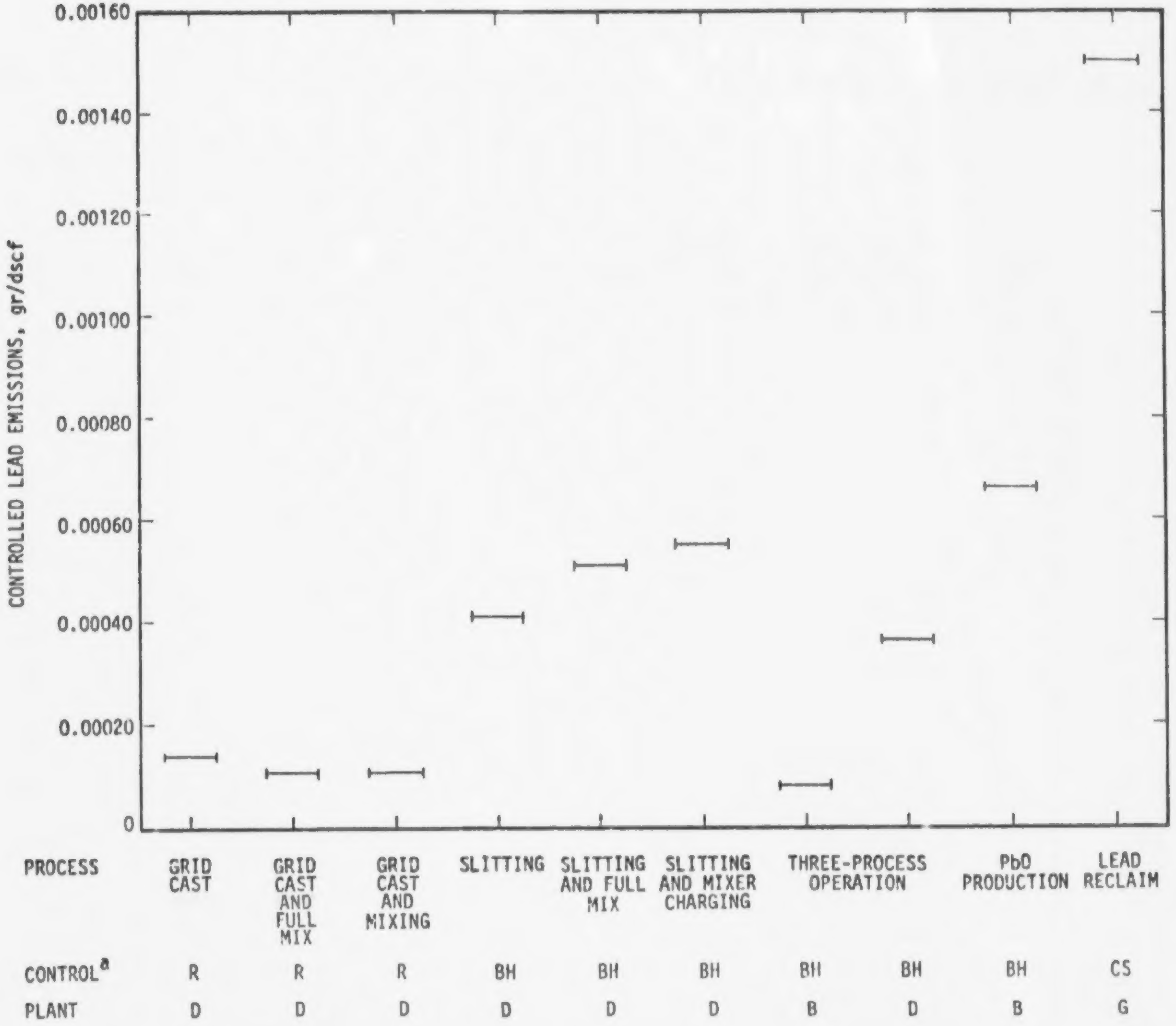


Figure 4-18. Average controlled lead emissions from tested facilities (gr/dscf).

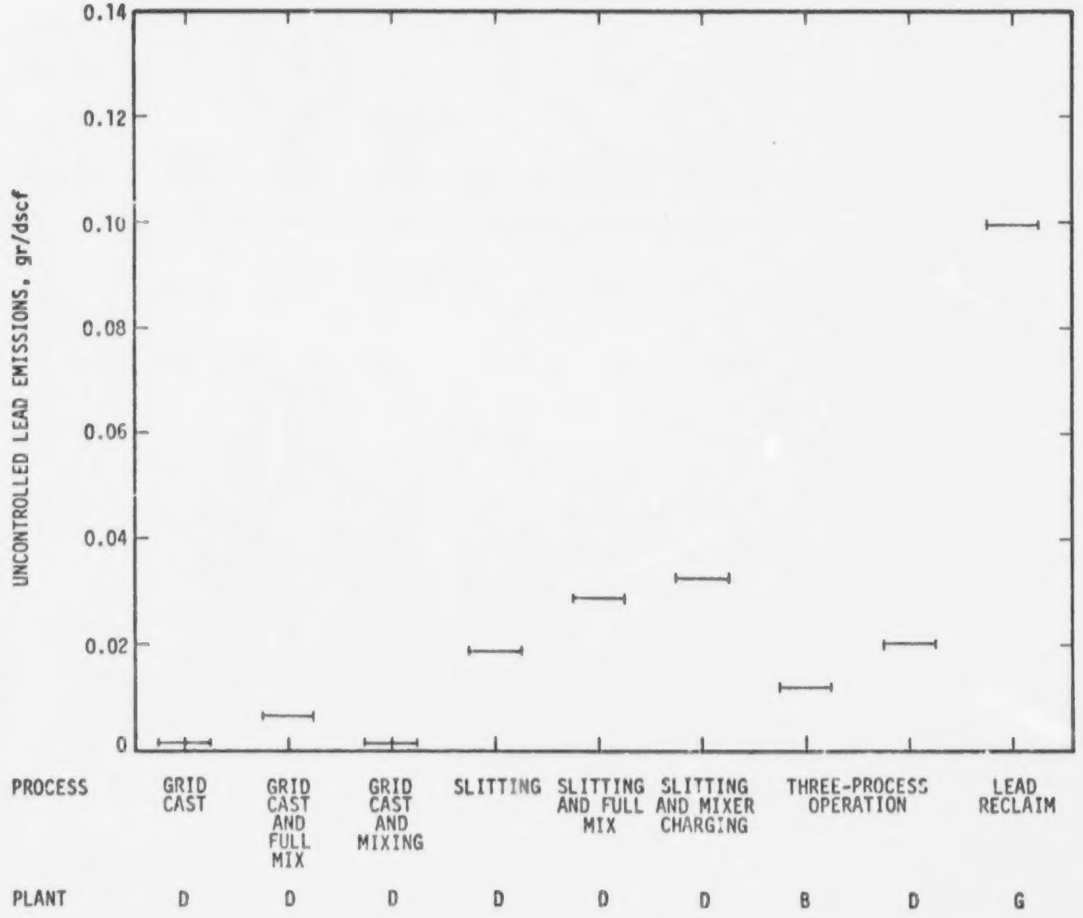


Figure 4-19. Average uncontrolled lead emissions from tested facilities (gr/dscf).

Table 4-1. CHARACTERISTICS OF CONTROL DEVICES TESTED

	Generic type of control device	Source (plant) code	Test Program Information				
			Specific type of device	Lead removal efficiency, percent	Air-to-cloth ratio	Water-to-gas ratio, $1/m^3$ (gal/1000 acf)	Pressure drop, Pa (in. W.G.)
Grid casting	Impingement and entrainment scrubber	D	Type N Roto-Clone	90	N/A	2.6 (20) (in motion)	1245 (5)
Paste mixing Materials charging	Baghouse	D	Shaker type	98	3/1	N/A	249 (1)
Mixing	Impingement and entrainment scrubber	D	Type N Roto-Clone	90	N/A	2.6 (20) (in motion)	1245 (5)
Three-process operation	Baghouse	B	Pulse jet type	99.3	6/1	N/A	1245 (5)
Lead oxide manufacturing	Baghouse	D	Shaker type	98.6	3/1	N/A	498 (2)
		B[a]	Shaker type (2)	b	4/1	N/A	249-498 (1-2)
			Pulse jet type (2)		2/1	N/A	1494 (6)
Lead reclamation	Centrifugal and impingement scrubber	G	Cascade scrubber	98.3[c]	N/A	0.53 to 0.70 (4-5)	498-747 (2-3)

[a] Four baghouses ducted to common stack.

[b] No inlet tests taken. Baghouses are considered process equipment (for product recovery) as well as control devices.

Source tests show 98 percent efficiency for this low-energy scrubber.

[d] Manufacturers' trade names have been used herein for purposes of clarity only. The use thereof shall not be deemed as an endorsement of any particular brand of equipment or substance by EPA.

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2. Ibid.

3. Private Communication between Mr. Lee Beck of the U.S. Environmental Protection Agency and Mr. Walter G. Schleyer of Philadelphia Quartz Company, December 28, 1977.

4. Private Communication between Mr. Lee Beck of the U.S. Environmental Protection Agency and Ms. Elizabeth Mahaffee of ESB Battery Company, Inc., December 28, 1977.

5. Private Communication between Mr. Lee Beck of the U.S. Environmental Protection Agency and Mr. Robert Nicholi of Globe-Union, Inc., December 28, 1977.

6. Kulujian, N. Test 74-BAT-1, ESB Incorporated, Milpitas, California. PEDCo-Environmental Specialists, Inc. Prepared for U.S. Environmental Protection Agency under Contract No. 68-02-0237, Task No. 28. March 1974. p. 9.

7. Trip Report, Standard Electric Company, San Antonio, Texas. PEDCo-Environmental Specialists, Inc. Prepared for the U.S. Environmental Protection Agency under Contract No. 68-02-2085. December 10, 1975.

8. Lindsey, A.M., and Segars, R. Control of Particulate Emissions from Phosphate Rock Dryers. Environmental Protection Agency, Region IV, Atlanta, Georgia. January, 1974. p. 6.

9. Control Techniques for Particulate Air Pollutants, Environmental Protection Agency, Publication No. AP-51. January, 1969. p. 125.

10. Private Communication between Mr. Lee Beck of U.S. Environmental Protection Agency, and Mr. Robert Nicholi of Globe-Union, Inc. April 20, 1976.

11. Report on Source Testing of Five Process Stacks for ESB-Canada, Limited, Mississauga, Ontario. Enviroclean, Limited. Willowdale, Ontario, August, 1974.

12. Particulate and Lead Emission Measurements from a Lead Oxide Plant. Monsanto Research Corporation. Prepared for the U.S. Environmental Protection Agency under Contract No. 68-02-0226, Task No. 10. 1973. p. 17.

13. Private Communication between Mr. Lee Beck of U.S. Environmental Protection Agency and Mr. Leland Robinson, Delco-Remy Division of General Motors Corporation. January 12, 1977.

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15. Ibid.

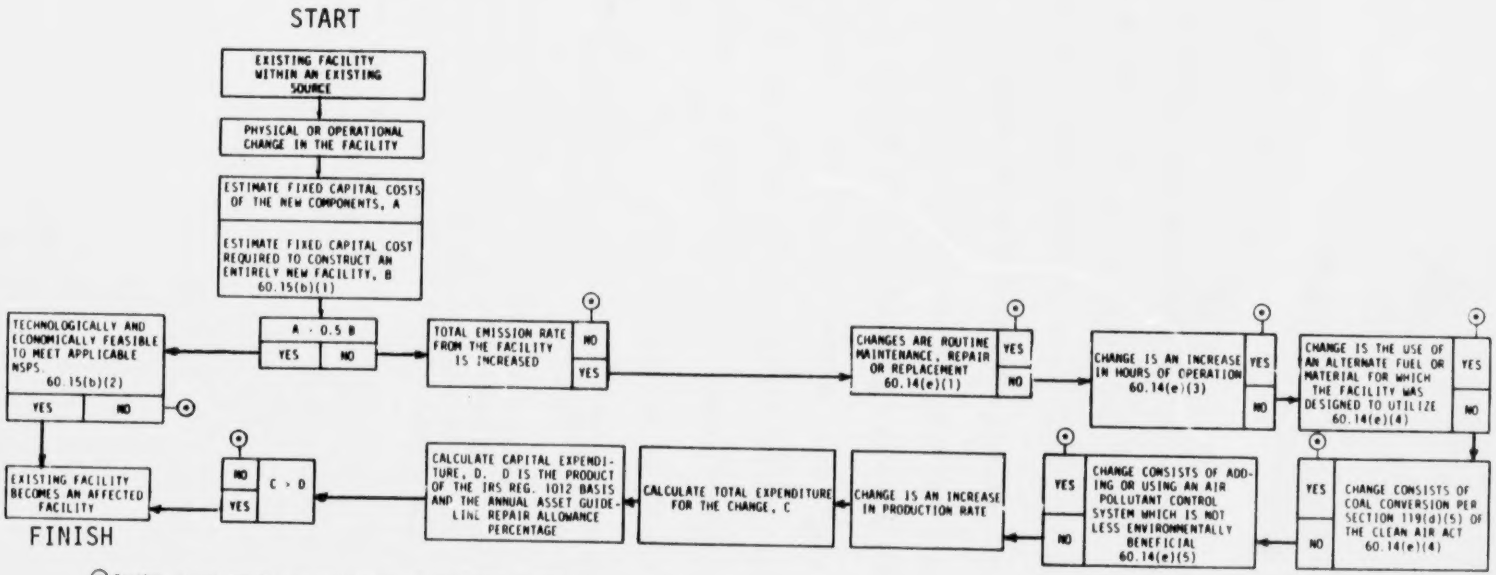
5.0 MODIFICATIONS AND RECONSTRUCTION

5.1 GENERAL

New Source Performance Standards apply to new, modified, and reconstructed facilities. Therefore, existing facilities are not affected until a modification or reconstruction is determined to have taken place. The definitions of modification and reconstruction are presented in the general provisions applicable to all New Source Performance Standards in 40 CFR 60.14 and 60.15 and are discussed in this chapter.

A step-by-step approach to determining whether a physical or operational change constitutes a modification or reconstruction under the regulations is shown in Figure 5-1. Following are simplified definitions of some of the terms used in the regulations:

- Source - Generally an entire plant or process consisting of more than one facility.
- Facility - A particular operation within a source. For example, in a lead-acid battery plant, the grid casting operation, the paste mixing operation, the three-process operation, etc., would be considered as separate facilities.
- Affected Facility - One that is subject to the emission limitations of an NSPS. An affected facility is one that is newly built or one that has been modified or reconstructed.


START
EXISTING FACILITY WITHIN AN EXISTING SOURCE
PHYSICAL OR OPERATIONAL CHANGE IN THE FACILITY
ESTIMATE FIXED CAPITAL COSTS OF THE NEW COMPONENTS, A
ESTIMATE FIXED CAPITAL COST REQUIRED TO CONSTRUCT AN ENTIRELY NEW FACILITY, B 60.15(b)(1)
A > 0.5 B
YES
NO
TECHNOLOGICALLY AND ECONOMICALLY FEASIBLE TO MEET APPLICABLE NSPS. 60.15(b)(2)
YES
NO
TOTAL EMISSION RATE FROM THE FACILITY IS INCREASED
NO
YES
CHANGES ARE ROUTINE MAINTENANCE, REPAIR OR REPLACEMENT 60.14(e)(1)
YES
NO
CHANGE IS AN INCREASE IN HOURS OF OPERATION 60.14(e)(3)
YES
NO
CHANGE IS THE USE OF AN ALTERNATE FUEL OR MATERIAL FOR WHICH THE FACILITY WAS DESIGNED TO UTILIZE 60.14(e)(4)
YES
NO
CHANGE CONSISTS OF COAL CONVERSION PER SECTION 119(d)(5) OF THE CLEAN AIR ACT 60.14(e)(4)
YES
NO
CHANGE CONSISTS OF ADDING OR USING AN AIR POLLUTANT CONTROL SYSTEM WHICH IS NOT LESS ENVIRONMENTALLY BENEFICIAL 60.14(e)(5)
YES
NO
CHANGE IS AN INCREASE IN PRODUCTION RATE
CALCULATE TOTAL EXPENDITURE FOR THE CHANGE, C
CALCULATE CAPITAL EXPENDITURE, D. D IS THE PRODUCT OF THE IRS REG. 1012 BASIS AND THE ANNUAL ASSET GUIDELINE REPAIR ALLOWANCE PERCENTAGE
C > D
NO
YES
EXISTING FACILITY BECOMES AN AFFECTED FACILITY
FINISH

⊙ Facility is not deemed to be modified and is not subject to NSPS.

Figure 5-1. Method of determining whether changes to existing facility constitute a modification or reconstruction under 40 CFR 60.14 and 60.15.

5.1.1 Reconstruction

Irrespective of any change in pollutant emission rates, a replacement of components of an existing facility may be deemed a reconstruction of that facility if (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and (2) it is technologically and economically feasible to meet the applicable standards.

5.1.2 Modification

If a physical or operational change results in an increase in the rate of emission to the atmosphere of any pollutant to which an NSPS applies, the facility is deemed to be modified. Certain exceptions apply, as shown in Figure 5-1.

When the purpose of the change in a facility or operation is to increase production rates and such change causes an increase in emission rates, the facility is deemed modified only if the total expenditures (both capital and expense dollars) attributable to the change exceed the product of the facility's "1012 Basis" and the "Annual Asset Guideline Repair Allowance Percentage (AAGRAP)." The first figure is determined in accordance with Internal Revenue Code Section 1012. Very simply stated, it may be thought of as the initial cost, or basis, of the facility. The latter figure is given in Internal Revenue Service Publication 534 (latest edition). Table 5-1 lists the AAGRAP values applicable to various facilities for which NSPS regulations have been promulgated.

TABLE 5-1. ANNUAL ASSET GUIDELINE REPAIR ALLOWANCE PERCENTAGES FOR SPECIFIED FACILITIES PER IRS PUBLICATION 534 (1975 EDITION)

Facility	AAGRAP
Nitric acid production unit	5.5
Sulfuric acid production unit	5.5
Lead smelter cupola	4.5
Catalytic cracking unit at a petroleum refinery	7.0
Electric arc furnace	8.0

5.2 APPLICABILITY OF 40 CFR 60.14 AND 60.15 TO THE LEAD-ACID BATTERY MANUFACTURING INDUSTRY

5.2.1 Capital Costs of Facilities

In general, the cost of any piece of equipment represents approximately 25 to 33 percent of the total installed capital costs. Cost breakdowns for a typical installation are given in Tables 8-10 and 8-11. Estimated capital costs associated with the purchase of various components are shown in Table 5-2. As mentioned earlier, the replacement of components may be considered a reconstruction if the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility. Thus the replacement of a rotary mill in a lead oxide manufacturing facility would not be considered a reconstruction where the fixed capital cost of the mill is $45,000 and the total fixed capital costs of an entirely new facility would approximate $125,000.

5.2.2 Routine Maintenance, Repair, and Replacement[4]

Routine maintenance, repair, or replacement of components are specifically exempted under section 60.14(e)(1). Therefore it is important

Table 5-2. F.O.B. PRICE OF VARIOUS COMPONENTS FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES

Facility	Component	Capacity	Other specs	Cost, \$[a]
Grid casting	Furnace	1814 kg (4000 lb)		\$ 2,350
		2492 kg (5500 lb)		5,210
	Grid casting machine	18 grids/min		13,600
	Small parts casting machine			8,360
Paste mixing	Mixer	252 kg/sec (2000 lb/hr)	Includes motor	13,300
	Mixer	630 kg/sec (5000 lb/hr)	Includes motor	24,000
	Mixer	1134 kg/sec (9000 lb/hr)	Includes motor	33,100
Three-process operation	Automatic stackers	170 plates/min		21,900
	Automatic burning	4 btry/min		6,480
	Automatic assembly	100 btry/shift		3,440
		800 btry/shift		14,600
Formation	Rectifiers	3500 bpd		10,400
PbO manufacturer	Rotary mill	1 tph	With motor	15,700
	Conveyors and storage			8,350
	Baghouse	111 m^3/min (4000 cfm)		11,500
Lead reclamation	Pot furnace			5,220

[a] These estimates are based on mid-1976 dollars and are quotations obtained from vendors by telephone and from various cost estimating and equipment pricing guides. Costs for specific installations will vary. These figures can be used for "order of magnitude" estimates only.

to consider the physical changes that constitute routine maintenance, repair, or replacement.

Grid casting furnaces require periodic inspection and annual repairs such as relining. These furnaces are normally relined only five or six times and then are replaced. Grid casting machines are highly mechanized and therefore require periodic inspection and replacement of small parts and an annual complete overhaul. With a good maintenance program, a grid casting machine can operate for many years.

Paste mixers usually require considerable maintenance because operators tend to overload the equipment. Gears, shafts, drives, and other movable parts cannot sustain the mechanical attrition and must be replaced. The paste mixer shell and other stationary hardware can last for many years, however, requiring very little maintenance. Like the grid casting machine, the paste machine is highly mechanized and requires periodic inspections and annual overhauls. Replacement of chains, bearings, and drives is common.

Automatic stacking machines, burning machines, and group assembly machines require continual maintenance. Conveyor chains, bearings, and small parts are periodically replaced. These machines are also cleaned periodically and overhauled annually. At plants where the stacking, burning, and assembly are done manually, little if any routine maintenance is required.

Equipment for forming dry batteries may corrode during the years and eventually need replacement. Where batteries are formed in their cases, corrosion is not a problem. Although rectifiers can burn out if they are not adequately cooled, this is unlikely; they typically require no maintenance and last for many years. At one plant visited during this study the rectifiers were over 20 years old.

Lead oxide ball mills require routine repairs. The classifying screens of the rotary ball mill must be replaced about monthly. Bearings and other small parts are replaced periodically. The shell of the mills will last up to 20 years before total replacement is necessary. The inner cast iron liner of the impact mill must be replaced annually. Fabric filter bags are normally replaced annually. Screw conveyors from the baghouse are likely to jam frequently and require regular maintenance.

Barton pots also require periodic relining and other minor repairs. Eventually these pots must be replaced.

5.2.3 Use of Alternative Materials

In general, the same materials have been used in lead-acid batteries ever since self-starters were put on automobiles. Almost by definition, they cannot be replaced with alternative materials. Alloy metals are sometimes added to the lead, usually at the smelter. In brief, the exemption cited in section 60.14 (e)(4) relative to the use of alternative materials has little application to the manufacture of lead-acid batteries.

The only foreseeable application of this section would relate to paste mixing. The mixing facility is designed to mix oxides derived from both ball mills and Barton pots. Because some regard the latter as finer and more difficult to contain and capture,[5] it is possible that use of Barton pot oxides could cause relatively greater emissions from the mixer. (None of the industry spokesmen contacted had information in this regard; one pointed out that because both oxides are often ground in a hammermill as a final step, the particle characteristics may be similar). Use of various alternate materials as binders and expanders also may increase emissions from the mixer. Even old paste is sometimes ground for use in the negative paste mix. Under section 60.14(e)(4), such a change in the use of materials would not be deemed a modification if the mixer was designed to accommodate the alternative material.

5.2.4 Use of Different Control Device

Section 60.14(e)(5) provides an exemption where an increase in pollutant emission rate is due to the addition or use of any system or device whose primary function is the reduction of air pollutants and it is determined by the Administrator of EPA that such system is not less environmentally beneficial than the original system. An example of this is replacement of a 99.9 percent efficient scrubber (from which lead-contaminated water emanates) with a 99.7-percent-efficient dry collector such as a fabric filter. Replacement of the same scrubber with a 70-percent-efficient cyclone would be considered less environmentally beneficial and thus a modification.

5.2.5 Increase in Production Rate Accomplished Without a Capital Expenditure

If the purpose of a physical or operational change is to increase the production rate and if such change results in an increase in emission rate, the facility will be considered a modified facility only if the total costs associated with the change constitute a capital expenditure. If the total costs are lower than those constituting a capital expenditure, such change is not considered a modification (section 60.14[e][2]). Capital expenditure is the product of the IRS Regulation 1012 Basis and the Annual Asset Guideline Repair Allowance Percentage (AAGRAP). The 1977 Edition of IRS publication 534 sets the AAGRAP at 5.5 percent for the lead-acid battery industry. Simply stated, therefore, if the total cost of the change exceeds 5.5 percent of the original cost of the facility, the change could constitute a modification.

5.3 ILLUSTRATIVE EXAMPLES

The enforcement division of the appropriate EPA regional office should be contacted whenever a source has questions regarding modifications and reconstruction. Their judgment will supercede any general examples that can be given in a document such as this. However, some examples are offered below, showing how the regulation might apply to the lead-acid storage battery industry.

As one example, consider a grid casting facility with a 1012 basis of $515,000. If the furnace is changed to increase production and the change results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies, the change will be considered a modification if the cost exceeds $28,325 (5.5 percent of $515,000).

As another example, if a plant operator replaces the motor, paddle wheel and shell of his paste mixer, the repaired mixer will be subject to the new source performance standards, even if emissions to the atmosphere are not increased. This is assuming that the cost of the new components of the repaired mixer "exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility [mixer]" and that "it is technically and economically feasible to meet the applicable standards" (Section 60.15).

REFERENCES FOR SECTION 5

1. Federal Register, Vol. 40, No. 242. Tuesday, December 16, 1975. p. 58416.
2. Private Communication between David Augenstein of PEDCo Environmental, Inc., Cincinnati, Ohio, and Sam Hurley of Winkel Machine Co., Inc. Kalamazoo, Michigan. January 1976.
3. Private Communication between David Augenstein of PEDCo Environmental, Inc., Cincinnati, Ohio, and George Tiegel of the Tiegel Manufacturing Co. Belmont, California. January 1976.
4. Private Communication between David Augenstein of PEDCo Environmental, Inc., Cincinnati, Ohio, and John Collinson of ESB Canada Limited, Toronto, Ontario. February 1976.
5. Private Communication between Donald Henz of PEDCo Environmental, Inc., Cincinnati, Ohio, Lee Beck of U.S. Environmental Protection Agency, and Robert Stuart of Globe Union, Canby, Oregon. June 14, 1976.

6.0 EMISSION CONTROL SYSTEMS

This chapter describes emission control systems that are considered likely candidates to represent the best system of emission reduction. An emission control system is a combination of a production process or type of process equipment (Chapter 3) and an emission control technique (Chapter 4). In the lead-acid battery industry there are no significant differences in types of process equipment that would limit the use of one control technique and dictate use of another. For most of the process operations, however, there is the choice of providing a wet collector or a fabric filter. None of the operations requires the use of a series of control devices, such as cyclone, baghouse, and afterburner. (When a baghouse is preceded by a cyclone at a lead oxide production facility, the cyclone is considered part of the process equipment. The baghouse is also part of the process to the extent of economic removal of valuable lead-oxide from the stack gas. The capacity of the baghouse to remove lead oxide beyond the point where it is economical is considered capacity added for emission control).

Given the definition of a control system as consisting of a production process together with a specific control technique, the next step is to develop a set of control "alternatives"; these are strategies for combining the various processes with the available control techniques to achieve optimum reduction of lead emissions throughout an entire plant. The selected alternatives, or strategies, discussed in this chapter are later considered in terms of their environmental impacts (Chapter 7) and economic impacts (Chapter 8).

6.1 APPLICATION OF CONTROL TECHNIQUES

The applicability and performance of a control technique with respect to a specific facility or group of facilities depend on the characteristics of the exhaust gas and particles, and on the operational characteristics of the control device and the facility. Other lead-emitting operations, such as slitting or lug breaking, can be ducted to any device controlling lead emissions from another facility. Table 6-1 summarizes the control systems that are, or could be, applied to well-controlled facilities in lead-acid battery manufacturing plants.

6.2 SELECTED CONTROL ALTERNATIVES

As discussed earlier, some facilities may be vented to common control systems. The possible combinations are many. Eight control alternatives for lead emissions are presented in Table 6-2. Control alternatives I through V are applicable to plants of production capacity greater than 500 batteries per day. Small plants (production capacity less than 500 bpd) typically do not have lead oxide manufacture and lead reclamation facilities. Also, it is expected that the economic impact of requiring emission controls on small plants will be more severe than on larger plants. Therefore, control alternatives VI, VII, and VIII are presented to give consideration to small producers of lead-acid batteries.

Selection of these eight alternatives is based on current applications, engineering judgement, and in the cases of systems I, VI, and VII, technology transfer. It is emphasized that these alternatives are not equally effective in abating lead emissions. All eight alternatives include a fiber mist eliminator for acid mist control.

Table 6-1. SUMMARY OF CONTROL SYSTEMS APPLICABLE TO LEAD-ACID BATTERY MANUFACTURING FACILITIES

Facility	Control technique				
	Impingement and entrainment scrubber 1245 PA (in W.G.) 2.6 l/m^3 (20 gal/1000 acfm)	Cascade scrubber 498 - 747 Pa (2-3 in W.G.) 0.14-0.67 l/m^3 (4-5 gal/1000 acf)	Fabric filter 6/1 A/C pulse jet	Fabric filter 2/1 A/C shaker	Mist eliminator
Grid casting furnace	X		X[a]		
Grid casting machine	X		X		
Paste mixer	X		X		
Three-process operation	X		X		
Lead reclamation furnace	X	X	X[a]		
Formation					X
Lead oxide mill				X	

[a] Based on technology transfer.

Table 6-2. SELECTED CONTROL ALTERNATIVES FOR LEAD-ACID BATTERY MANUFACTURING INDUSTRY

Plant size, BPD	Control alternative	Facilities[a]	Control system[b]
500, 2000, & 6500	I	A, B, F	Fabric filter, 6/1 A/C
		C, E	Fabric filter, 6/1 A/C
		G	Mist eliminator
		D	Fabric filter, 2/1 A/C
	II	B, C, E	Fabric filter, 6/1 A/C
		F	Impingement and entrainment scrubber
		A	Impingement and entrainment scrubber
		G	Mist eliminator
		D	Fabric filter, 2/1 A/C[c]
	III	C, E	Fabric filter, 6/1 A/C
		A, B, F	Impingement and entrainment scrubber
		G	Mist eliminator
		D	Fabric filter, 2/1 A/C
	IV	A, B, C	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C
		F	Impingement and entrainment scrubber
		G	Mist eliminator
		D	Fabric filter, 2/1 A/C[c]
	V	A, B, C, F	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C
		G	Mist eliminator
		D	Fabric filter, 2/1 A/C[c]
100 & 250[d]	VI	A, B, C	Fabric filter, 6/1 A/C
		E	Fabric filter, 6/1 A/C
		G	Mist eliminator
	VII	A, B, C, E	Fabric filter, 6/1 A/C
		G	Mist eliminator
	VIII	A, B, C	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C
		G	Mist eliminator

[a] Facilities key: A - grid casting furnace; B - grid casting machines; C - paste mixer; D - lead oxide manufacturing; E - three-process operation; F - lead reclamation furnace; G - formation.

[b] Facilities are vented to common control systems as shown.

[c] Small plants (500 bpd or less) are assumed to have no lead oxide manufacturing facilities.

[d] Plants smaller than 500 BPD are assumed to have no lead reclamation facilities.

Electrostatic precipitators and high energy scrubbers are commonly used to control particulate emissions from other industries. They are not considered in any of the control alternatives in this study because they are not used in the lead-acid storage battery industry, and have no economic or environmental advantage over fabric filters.

6.3 EFFECTIVENESS OF SELECTED LEAD EMISSIONS CONTROL SYSTEMS

Approximate uncontrolled lead emission rates of the facilities used in lead-acid battery plants are presented in Table 6-3. These have been calculated using emission testing data presented and discussed in Chapter 4. The emission reduction which would result from the use of any one of the selected control alternatives can be calculated using the collection efficiencies of the control system components (see Table 6-4). Tables 6-5 and 6-5A compare the expected lead emission rates of 500, 2000, and 6500 bpd plants using control alternatives I through V and 100 and 250 bpd plants using alternatives VI through VIII with the approximate emission rates of plants using no emission controls. Tables 6-6 and 6-6A compare the expected lead emission rates of plants using the selected control alternatives with the expected emission rates of plants controlling emissions only to the extent required by typical State regulations. State Implementation Plan (SIP) regulations generally limit particulate emissions from a process to a percentage of the throughput of the process. In order for a lead-acid battery plant to comply with typical SIP regulations, emissions from the paste mixing and lead reclamation facilities generally must be controlled (uncontrolled emissions from lead oxide production facilities, grid casting facilities and three-process facilities generally do not exceed SIP limits). SIP emission rates presented in Tables 6-6 and 6-6A were

Table 6-3. UNCONTROLLED EMISSIONS OF LEAD FROM LEAD-ACID BATTERY MANUFACTURING FACILITIES[a]

Facility code	Facility description	Lead emissions		
		$\mu g/m^3$ (gr/scf)	g/1000 btry (lb/1000 btry)	g/kg Pb throughput (lb/ton Pb throughput)
A	Grid casting furnace	0.094[b] (0.00116)	408[b] (0.90)[b]	
B	Grid casting machine			
C	Paste mixing	1.07 (0.0132)	5079 (11.2)	
D	PbO manufacturing	0.107 (0.00132)[c]	53 (0.116)[c]	0.01 (0.02)[c]
E	Three-process operation	1.33 (0.0163)	6666 (14.7)	
F	Lead reclamation	8.14 (0.10)	349 (0.77)	2.95 (5.9)

[a] Based on source test data from Plants B, D, and G.

[b] Facilities A and B were vented to a single control device. It is estimated that 50 percent emanates from each facility. Figures represent emissions from both facilities.

[c] This number is twice the value measured in tests at the outlet of a well-controlled facility.

TABLE 6-4. ESTIMATED LEAD COLLECTION EFFICIENCIES OF SELECTED CONTROL SYSTEMS

Control device	Lead collection efficiency, %
Fabric filter, 2/1 A/C	50[a]
Fabric filter, 6/1 A/C	99
Impingement and entrainment scrubber	90

[a] It is estimated that well-controlled lead oxide manufacturing facilities emit only half as much lead as one designed only for economical recovery of lead oxide. Hence only a 50 percent efficiency is stated.

Table 6-5. EFFECT OF CONTROL ALTERNATIVES ON LEAD EMISSIONS FROM VARIOUS SIZED BATTERY MANUFACTURING PLANTS

Control alternative[a]	Plant size, bpd	Lead emissions, kg/day		percent removal
		Uncontrolled	Controlled	
I	500	6.25	0.063	99.0
	2000	25.1	0.291	98.8
	6500	81.6	0.988	98.8
II	500	6.25	0.088	98.6
	2000	25.1	0.388	98.4
	6500	81.6	1.311	98.4
III	500	6.25	0.098	98.4
	2000	25.1	0.424	98.3
	6500	81.6	1.43	98.3
IV	500	6.25	0.326	94.8
	2000	25.1	1.31	94.8
	6500	81.6	4.38	94.6
V	500	6.25	0.326	94.8
	2000	25.1	1.31	94.8
	6500	81.6	4.41	94.6
VI	100	1.22	0.0122	99.0
	250	3.04	0.0304	99.0
VII	100	1.22	0.0122	99.0
	250	3.04	0.0304	99.0
VIII	100	1.22	0.0615	94.9
	250	3.04	0.1540	94.9

[a] Table 6-2 describes the selected control alternatives.

Table 6-5A. EFFECT OF CONTROL ALTERNATIVES ON LEAD EMISSIONS FROM VARIOUS SIZED BATTERY MANUFACTURING PLANTS

(English Units)

Control alternative[a]	Plant size, bpd	Lead emissions, lb/day		percent removal
		Uncontrolled	Controlled	
I	500	13.8	0.138	99.0
	2000	55.3	0.665	98.8
	6500	180	2.18	98.8
II	500	13.8	0.193	98.6
	2000	55.3	0.885	98.4
	6500	180	2.89	98.4
III	500	13.8	0.214	98.4
	2000	55.3	0.940	98.3
	6500	180	3.15	98.3
IV	500	13.8	0.718	94.8
	2000	55.3	2.88	94.8
	6500	180	9.67	94.6
V	500	14.8	0.718	94.8
	2000	55.3	2.88	94.8
	6500	180	9.73	94.6
VI	100	2.68	0.0268	99.0
	250	6.70	0.0670	99.0
VII	100	2.68	0.0268	99.0
	250	6.70	0.0670	99.0
VIII	100	2.68	0.136	94.9
	250	6.70	0.339	94.9

[a] Table 6-2 describes the selected control alternatives.

Table 6-6. EFFECT OF CONTROL ALTERNATIVES ON LEAD EMISSIONS COMPARED WITH SIP CONTROLS

Control alternative[a]	Plant size, bpd	Lead emissions, kg/day SIP Controls	Lead emissions, kg/day NSPS Controls	Percent Improvement
I	500	3.81	0.063	98.3
	2000	15.3	0.291	98.0
	6500	49.8	0.988	98.0
II	500	3.81	0.088	97.7
	2000	15.3	0.388	97.4
	6500	49.8	1.311	97.4
III	500	3.81	0.098	97.4
	2000	15.3	0.424	97.2
	6500	49.8	1.43	97.2
IV	500	3.81	0.326	91.4
	2000	15.3	1.31	91.4
	6500	49.8	4.38	91.1
V	500	3.81	0.326	91.4
	2000	15.3	0.31	91.4
	6500	49.8	4.41	91.1
VI	100	0.76	0.0122	98.4
	250	1.90	0.0304	98.4
VII	100	0.76	0.0122	98.4
	250	1.90	0.0304	98.4
VIII	100	0.76	0.0615	91.9
	250	1.90	0.154	91.9

[a] Table 6-2 describes the selected control alternatives.

Table 6-6A. EFFECT OF CONTROL ALTERNATIVES ON LEAD EMISSIONS COMPARED WITH SIP CONTROLS

(English Units)

Control alternative[a]	Plant size, bpd	Lead emissions, lb/day		Percent Improvement
I	500	8.38	0.138	98.3
	2000	33.7	0.665	98.0
	6500	109	2.18	98.0
II	500	8.38	0.193	97.7
	2000	33.7	0.885	97.4
	6500	109	2.89	97.4
III	500	8.38	0.214	97.4
	2000	33.7	0.94	97.2
	6500	109	3.15	97.2
IV	500	8.38	0.718	91.4
	2000	33.7	2.88	91.4
	6500	109	9.67	91.1
V	500	8.38	0.718	91.4
	2000	33.7	2.88	91.4
	6500	109	9.73	91.1
VI	100	1.67	0.0268	98.4
	250	4.18	0.067	98.4
VII	100	1.67	0.0268	98.4
	250	4.18	0.067	98.4
VIII	100	1.67	0.136	91.9
	250	4.18	0.339	91.9

[a] Table 6-2 describes the selected control alternatives.

obtained by assuming 90 percent control of paste mixing and lead reclamation emissions. All of the emission rates predicted in Tables 6-5, 6-5A, 6-6, and 6-6A were calculated with the assumption that 500 bpd plants do not have lead oxide production facilities and plants smaller than 500 bpd do not have lead oxide production or lead reclamation facilities.

7.0 ENVIRONMENTAL IMPACT

The projected impacts of each alternative control system on ambient air, water quality, solid waste, energy demand, and other concerns are discussed in this chapter. These are presented in terms of incremental impacts and are compared with the impacts of uncontrolled sources and sources controlled to meet existing State regulations.

7.1 AIR POLLUTION IMPACT

7.1.1 Lead Emissions

Lead acid rates from lead-acid battery plants of various sizes are discussed in Chapter 6. The ambient impacts of these emissions, and their health impacts and national impacts, are discussed below. Existing standards which apply to lead acid battery plants are also discussed.

7.1.1.1 Ambient Impact--

A point source atmospheric dispersion model, CRSTER, was used to approximate ambient concentrations of lead around typical 500 and 6500 bpd lead acid battery plants.

The single-source CRSTER model is a steady-state, Gaussian-plume-dispersion model designed for point-source applications. It calculates pollutant concentrations for each hour of a year at 180 selected receptor sites. The hourly concentrations are averaged to obtain concentration estimates for time increments of specified length, such as one hour, 24 hours, and 1 year.

Input to the model consists of the pollutant source characteristics and a file of hour-by-hour dispersion conditions. The source characteristics include the emission rate, stack height, stack diameter (inner), and stack-gas temperature and exit velocity. The file of hour-by-hour dispersion conditions is developed by a pre-processor program from weather observations recorded over a 1-year period. Currently, the weather data are from 1964 records.

The lead emission rates used as input to the model were based on data from the EPA test program. The 500 bpd model plant does not include a lead oxide mill or lead reclamation facility, and emissions estimated from the test data for a 6500 bpd model plant include emissions from lead reclamation, slitting, and the lead oxide mill.

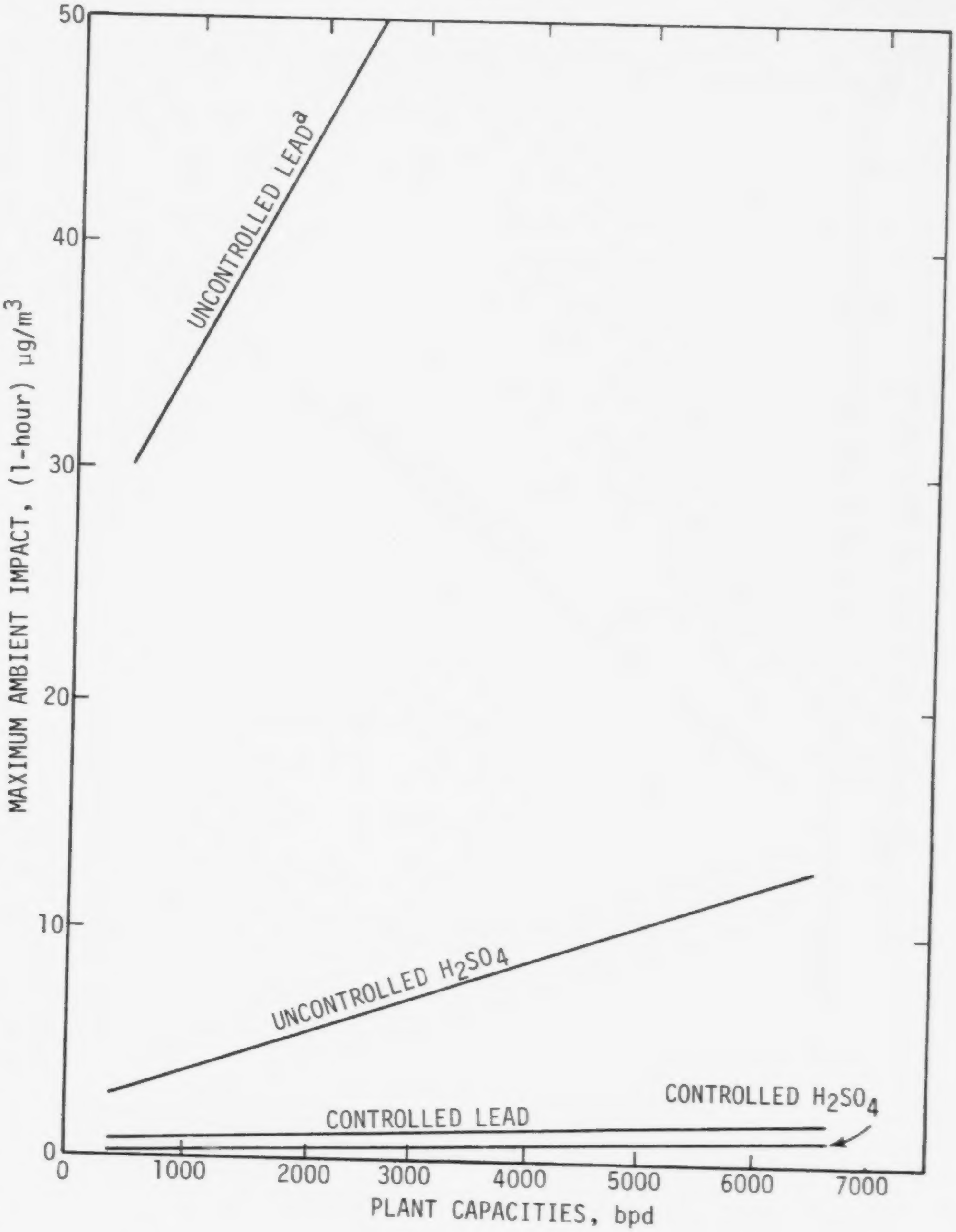
Figures 7-1, 7-2, and 7-3 and Table 7-1 present the maximum impacts on ambient air of emissions from battery plants with and without NSPS controls. Emission rates used for the uncontrolled cases are those for plants controlling emissions only to the extent required by SIP particulate regulations (see Table 6-6). The emission rates used for the controlled cases are those for plants using control alternative 1 (fabric filter control of all lead emissions).

7.1.1.2 Health Effects of Lead Emissions--

Airborne lead is believed to contribute to increased lead levels in man.[2] However, it is outside the scope of this study to detail health effects. The reader is directed to the EPA document titled "Air Quality Criteria for Lead"[3] for a comprehensive discussion of the health effects of lead emissions.

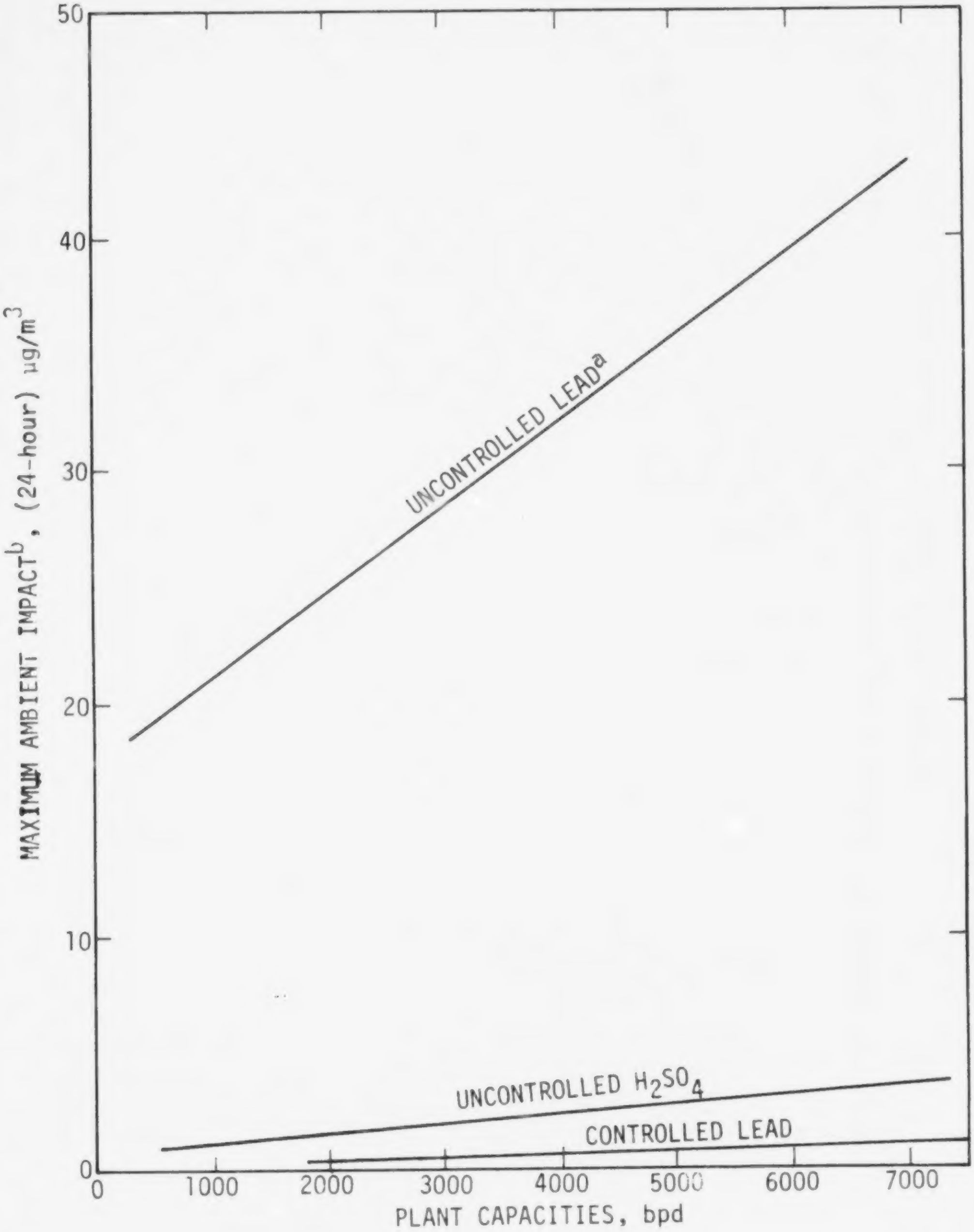
7.1.1.3 Nationwide Emissions of Lead--

U.S. total lead consumption in 1975 was 1200 Gg (1,270,000 tons) of which 617 Gg (680,000 tons) was used in storage batteries.[4] Total



[a] Controlled only to the extent required by typical SIP regulations.

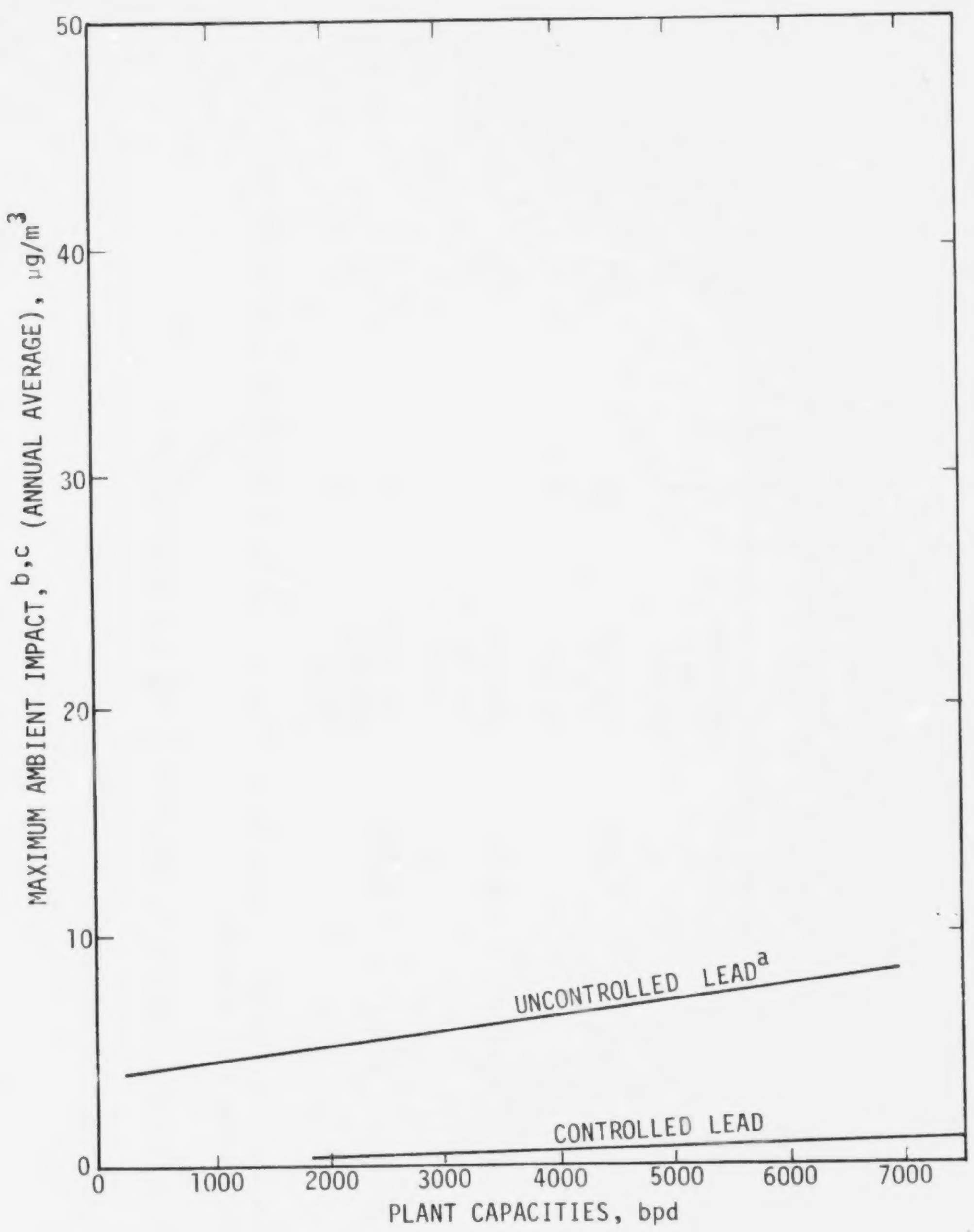
Figure 7-1. Maximum ambient impact of lead-acid battery manufacturing plants for various plant production rates - 1-hour maximum.



[a] Controlled only to the extent required by typical SIP regulations.

[b] The ambient impact of controlled acid mist emissions is less than 1 µg/m^3 and is not shown.

Figure 7-2. Maximum ambient impact of lead-acid battery manufacturing plants for various plant production rates - 24-hour maximum.



[a]Controlled only to the extent required by typical SIP regulations.

[b]The ambient impacts of both controlled and uncontrolled acid mist emissions are less than 1 μg/m^3 and are not shown.

[c]The maximum ambient impact is at 50 m from the source.

Figure 7-3. Maximum ambient impact of lead-acid battery manufacturing plants for various plant production rates - Annual mean.[a]

Table 7-1. APPROXIMATE EMISSION RATES[a] AND MAXIMUM RESULTANT GROUND-LEVEL LEAD AND SULFURIC-ACID MIST CONCENTRATIONS FOR TWO PLANT SIZES

Control status	Plant size, bpd	Lead emissions, g/sec	Sulfuric-acid mist emissions, g/sec	Averaging time	Maximum lead ambient concentrations, μ/m^3	Maximum H_2SO_4 ambient concentrations, μg/m^3
Uncontrolled[b]	500	0.13	.007	one-hour	31	3
				24-hour	19	1
				annual	4	<1
	6500	0.58	0.096	one-hour	88	13
				24-hour	41	3
				annual	8	<1
Controlled[c]	500	0.0022	0.0004	one-hour	1	<1
				24-hour	<1	<1
				annual	<1	<1
	6500	0.0114	0.005	one-hour	2	1
				24-hour	1	<1
				annual	<1	<1

[a] Data basis: EPA source test program.

[b] Subject to SIP particulate regulations on paste mixing and lead reclaim.

[c] Per control alternative 1 (see Table 6-2).

annual atmospheric emissions of lead are estimated at 194 Gg (214,000 tons),* of which approximately 82 Mg (90 tons) originate from battery manufacturing processes (See Chapter 3.0).

7.1.1.4 Current Standards for Lead--

The ambient criteria standard for lead is 1.5 mg/m^3 averaged over a calendar quarter. In Ontario, Canada, lead emissions may not impart a calculated downwind concentration of more than 10 μmg/m^3 (30 minutes) using the Pasquill-Gifford equations. Measured downwind concentrations may not exceed 5 μg/m^3 (24-hour) and 2 μg/m^3 (30-day). Montana and Pennsylvania have set ambient air standards for lead at 5 μg/m^3 (30-day). Reportedly the most stringent standard is that of the USSR, 0.7 μg/m^3, 24-hour average.

7.1.2 Sulfuric-Acid Mist Emissions

Both the wet and dry formation processes generate sulfuric acid mist. Emission data are sparse. One report indicates an emission rate of 14 kg (30 lb) of sulfuric acid (H_2SO_4) mist per 1000 batteries.[7] Another report[8] estimates an emission factor of 19 kg (42 lb) acid mist per 1000 batteries.

In wet formation, battery plates are formed in individual, preassembled battery cases. Based on plant observations, the slow rate of charging (one to four days), and the fact that there is usually a lid or cap on the assembled battery, sulfuric acid mist emissions to the atmosphere from wet formation are believed to be small.

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*Estimated from Reference 5 and 6 by the following method:

$$\frac{\text{1975 lead consumption}}{\text{1970 lead consumption}} \times \text{1970 emissions} = \text{1975 lead emissions}$$

During dry formation, battery plates are formed prior to battery assembly in open vats over a shorter formation cycle (16 hours) and therefore emissions are more of a problem. Because the release of hydrogen bubbles in the formation process increases with time, emissions are greater towards the end of the cycle.

EPA tests on the dry formation process at a 6000 battery per day plant showed average uncontrolled sulfuric acid mist emissions of 66 mg/m^3 during the last 5 hours of the formation cycle (about 1.1 kg [2.4 lb] of sulfuric acid mist per 1000 batteries). Emissions of sulfuric acid mist can generally be controlled 95 to 99 percent by use of fiber mist eliminators.

7.1.2.1 Ambient Impact--

As with lead, the CRSTER model was used to approximate the ambient concentrations of sulfuric-acid mist. The emission rates used as input to the model were based on EPA test data from a dry formation process at Plant L. Figures 7-1, 7-2, and 7-3, and Table 7-1 indicate the maximum impacts on ambient air of emissions from uncontrolled and well controlled sources. It was assumed that a well controlled formation facility would be equipped with a mist eliminator that was 95 percent efficient for sulfuric acid mist collection.

7.1.2.2 Health Effects of Sulfuric-Acid Mist Emissions--

Short-term human exposure to sulfuric-acid mist can cause temporary and permanent damage to the lungs and bronchial tubes. Long-term exposure can cause skin damage, inflamation of the eyes, mouth, and stomach, and permanent tooth damage.[9,10]

7.1.2.3 Current Standards for Sulfuric Acid Mist--

Emissions of sulfuric acid mist from formation processes are generally unregulated. One State limits these emissions to 357 mg/m^3 (0.156 gr/dscf).[11] However, the concentrations of acid mist in exhausts from wet formation rooms are generally below this level.[12] Table 7-2 lists the allowable ambient air concentrations of sulfuric acid mist in several jurisdictions.

TABLE 7-2. ALLOWABLE AMBIENT AIR CONCENTRATIONS OF SULFURIC ACID MIST

	Allowable concentration for various average times, $\mu g/m^3$		
Jurisdiction	Maximum	1-hr	24-hr
Montana		30	
Missouri			10
New York	100		

7.1.3 Secondary Air Pollution Impact

All of the control alternatives described in Section 6 (see Table 6-2) would require the use of fans to drive exhaust gases through particle collection devices. These fans would require electrical energy, and, because relatively low concentrations of lead are emitted at lead-acid battery plants, the amount of energy required to collect 1 pound of pollutant would be high.

The generation of electricity results in a certain amount of air pollution, therefore, standards of performance for the lead-acid battery manufacturing industry would have a negative secondary air pollution impact. This impact can be estimated using the power requirements of

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*These figures do not include energy used by of lead removed by SIP control equipment (see section 7.1.1).

emission controls and the proposed standards of performance for new, modified, and reconstructed electric utility steam generating units.[13] For each kilogram of lead collected as a result of NSPS controls (Alternate I), approximately 23 grams of NO_x, 40 grams of SO_2, and 3 grams of particulate matter would be emitted at a power plant. For each kilogram of mist collected, approximately 83 grams of NO_x, 144 grams of SO_2, and 12 grams of particulate matter would be emitted at a power plant. Thus, although there would be a negative secondary air pollution impact associated with the proposed standards, this impact would be small compared with the beneficial primary impact.

7.2 WATER POLLUTION IMPACT

Assessing the impacts of the control alternatives on water pollution requires data on uncontrolled effluent characteristics, excluding wastewater streams from air pollution control devices. The increase in pollutant loadings and discharge flow attributed to the application of wet collectors can then be determined and compared with the uncontrolled levels.

7.2.1 Effluent Characteristics

A typical lead-acid battery manufacturing plant generates approximately 250 liters (66.5 gal) of wastewater per battery manufactured.[14] This wastewater contains approximately 2 to 4 percent sulfuric acid, by weight, and less than 0.0025 percent lead by weight.[15] This water can be completely neutralized, and more than 90 percent of the lead can be removed in wastewater treatment facilities.[16]

7.2.2 Incremental Pollutant Loadings Due to Air Pollution Control Systems

The acid scrubbed from exhausts from the formation process adds to the overall burden of wastewater treatment. Essentially all of this, however, can be neutralized to the point that, for all practical purposes, no increase in pollution results from the formation facility controls.

Incremental lead loadings to the in-plant raw wastewater from wet collection devices can be estimated by assuming 90 percent collection efficiency of the wet collectors and 90 percent removal of lead in the scrubber liquor recirculation facility. At a recirculation rate of 0.5 l/m^3 (4.0 gal/1000 acf) and 5 percent recirculation tank overflow, a total increase in hydraulic flow and the concentration can be determined and compared with the manufacturing effluent data. Tables 7-3 and 7-3A show these parameters for four of the control alternatives described in Table 6-2 as applied to a 6500 bpd plant.*

7.2.3 Summary of Water Pollution Impact

Where wet collection techniques are used to control atmospheric lead emissions, the increase in lead discharged to municipal sewage systems or surface waters is predicted to range from 0.43 to 4.6 percent, depending on the control alternative selected. The increase in flow rates into a waste treatment system is anticipated to range from 1.1 to 2.4 percent. Where fabric filtration is used to control lead emissions, there will be no impact on water emissions. Therefore, it is concluded that control of the airborne pollutants will have no significant impact on water pollution.

7.3 SOLID WASTE IMPACT

7.3.1 Sources of Waste Materials

Tables 7-4 and 7-4A show the sources, quantities, and disposition of waste materials based on production of 1000 batteries.[17] All solid

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*Control alternative I does not incorporate wet control devices and therefore does not contribute to water pollution.

Table 7-3. LEAD CONTENT OF SCRUBBER BLOWDOWN AND EFFECT ON WASTEWATER SYSTEM OF A 6500-BPD PLANT (METRIC UNITS)

Control Alternative[a]	Scrubber controlled exhaust m^3/min.	effluent lead content,[b] kg/day	Scrubber blowdown			Increase in total plant effluent,%	
			Quantity,[c] lpm	Lead concentration,[d] mg/liter	Lead content,[e] kg/yr.	Flow[f]	Lead[g]
II	453	3.24	12	18.5	80	1.1	0.43
III	708	4.43	19	16.3	110	1.7	0.60
IV	977	34.2	26	90.9	854	2.4	4.6
V	977	34.2	26	90.9	854	2.4	4.6

[a] See Table 6-2.

[b] Assuming 90% collection efficiency.

[c] Assuming 540 l/m^3 recirculation rate and 5% overflow or blowdown.

[d] Directly from recirculation tank prior to final treatment.

[e] Assuming 90% efficient wet collector and 90% lead removal in recirculation tank.

[f] Based on 240 m^3 wastewater/1000 batteries (63,500 gal wastewater/1000 batteries).

[g] Based on 11.3 kg lead/1000 batteries (25 lb lead/1000 batteries).

Table 7-3A. LEAD CONTENT OF SCRUBBER BLOWDOWN AND EFFECTS ON WASTEWATER SYSTEM OF A 6500-BPD PLANT (ENGLISH UNITS)

Control Alternative[a]	Scrubber controlled exhaust, acfm	Scrubber effluent lead content,[b] lb/day	Scrubber Blowdown			Increase in total plant effluent, %	
			Quantity,[c] gpm	Lead concentration,[d] mg/l	Lead content,[e] TPY	Flow[f]	Lead[g]
II	16,000	7.14	3.2	18.5	0.089	1.1	0.43
III	25,000	9.77	5.0	16.3	0.122	1.7	0.60
IV	34,500	75.3	6.9	90.9	0.941	2.4	4.6
V	34,500	75.3	6.9	90.9	0.941	2.4	4.6

[a] See Table 6-2 for a description of each Control Alternative; Control Alternative I is not shown since it utilizes only dry control devices and does not add to the plant's hydraulic flow.

[b] Assuming 90% collection efficiency.

[c] Assuming 4.0 gal./acf recirculation rate and 5% overflow or blowdown.

[d] Directly from recirculation tank prior to final treatment.

[e] Assuming 90% efficient wet collector and 90% lead removal in recirculation tank.

[f] Based on 63,500 gal. wastewater/1000 batteries.

[g] Based on 25 lb lead/1000 batteries.

Table 7-4. SOURCES, QUANTITIES, AND DISPOSITION OF WASTE MATERIALS (METRIC UNITS)[16]

Type of waste	Source	Quantity kg/1000 batteries	Disposition
Dusts, dross, and rejected materials	Grid manufacturing	544 kg Pb	Reclaim
Lead and lead oxide paste	Paste preparation	36 kg Pb/PbO	Reclaim
Lead and lead oxide in rise waters	Pasting area	90 kg Pb/PbO in 1% solution	Wastewater treatment
Rejected plates	Plate curing	180 kg PbO 362 kg Pb	Reclaim
Rejected assembled elements	Three-process	180 kg PbO 362 kg Pb	Reclaim
Raw wastewater solutions	Pasting area formation battery rinsing	190 m^3 2-4% H_2SO_4 6-11 kg Pb	Wastewater treatment
Sludges	Wastewater treatment	Caustic neutralization - 10 kg Lime neutralization - 13.4 Mg	Landfill
Air Contaminants	Total plant	0.4-2 kg Pb/PbO	Reclaim

Table 7-4A. SOURCES, QUANTITIES, AND DISPOSITION OF WASTE MATERIALS (ENGLISH UNITS)[16]

Type of waste	Source	Quantity lb/1000 batteries	Disposition
Dusts, dross, and rejected materials	Grid manufacturing	1200 lb Pb	Reclaim
Lead and lead oxide paste	Paste preparation	80 lb Pb/PbO in	Reclaim
Lead and lead oxide in rinse waters	Pasting area	200 lb Pb/PbO in 1% solution	Wastewater treatment
Rejected plates	Plate curing	400 lb PbO 800 lb Pb	Reclaim
Rejected assembled elements	Three-process	400 lb PbO 800 lb Pb	Reclaim
Raw wastewater solutions	Pasting area formation battery rinsing	50,000 gallons 2-4% H_2SO_4 13-25 lb Pb	Wastewater treatment
Sludges	Wastewater treatment	Caustic neutralization - 22 lb Lime neutralization 29,400 lb	Landfill
Air contaminants	Total plant	1-5 lb Pb/PbO	Reclaim

wastes excluding wastewater treatment sludges are recycled directly to the manufacturing facilities, reclaimed in the plant, or shipped to a smelter.

Wastewater streams containing lead and sulfuric acid are treated by caustic or lime neutralization facilities. Lime treatment produces very large quantities of sludge, whereas caustic neutralization generates little solid waste. Caustic treatment is more costly than lime neutralization.

7.3.2 Waste Characterization

This discussion concerns only the waste generated by manufacturing processes and does not consider nonprocess waste generated in the form of rubbish.

7.3.2.1 Lead Items--

Defective lead parts such as grids, posts, and connectors are returned to the grid-casting lead pots or the small-parts lead pot. Plates are either sent to a smelter or separated by a tumbler into paste and grids. In the latter case, the paste is frequently used as an ingredient in the paste mixer and the grids are remelted in the reclamation furnace.

7.3.2.2 Separators--

Rejected separators may be used as spacers or shims in blocking the element in the container. Generally, separators that have become saturated with sulfuric acid must be discarded. This disposal accounts for very little solid waste, however.

7.3.2.3 Containers and Covers--

The current trend is toward polypropylene containers and covers, although some manufacturers still use rubber. Defective containers must be discarded. Polypropylene containers can be used as fuel in lead blast furnaces and therefore are often sent to a smelter. Some plants send cases to the manufacturer for recycling. In short, defective polypropylene cases do not enter the solid waste stream.

Rubber containers can break rather easily if dropped. Broken containers must be discarded, since they are not useful as fuel nor can they be recycled. Defective covers usually contain lead bushings, which are separated from the covers and sent to a smelter. Scrapped rubber containers and covers are treated as rubbish and are generally landfilled.

7.3.2.4 Finished Batteries--

Batteries that are found to be defective when they are partially or fully assembled are sent to a smelter for recycling. They do not enter the solid waste stream at the battery manufacturing facility.

7.3.2.5 Paste--

Positive paste that becomes contaminated must be discarded or used as an ingredient for negative paste. If the paste becomes hard or lumpy, it cannot be softened and must be discarded. This paste is sent to a smelter for refining.

7.3.2.6 Sulfuric Acid--

If sulfuric acid is discharged from a plant and is neutralized with lime, solid waste is generated at the effluent treatment facility. Well-managed operations seldom discard sulfuric acid. The acid dumped from wet charged batteries after the formation process is used in place of water to make acid of higher specific gravity, which is used for the final fill of the batteries. Thus the "used" acid is actually shipped out in the wet batteries.

7.3.2.7 Sludge--

Virtually all the process-related solid waste results from the treatment of battery plant effluent, which results from acid leakage and spillage, washing and rinsing of dry battery elements, and housekeeping (hosing the floors). A typical plant generates approximately 250 liters (66.4 gallons) of wastewater per battery produced.[18] This effluent is neutralized by treatment with lime or caustic soda. The former produces large amounts of sludge, approximately 13 Mg (15 tons) per 1000 batteries manufactured.[19] Caustic soda treatment produces less than 11.3 kg (25 lb) of sludge per 1000 batteries manufactured. Regardless of the neutralization method, the sludge contains approximately 2.5 kg (5.6 lb) $Pb(OH)_2$ and 5.3 kg (11.7 lb) $PBSO_4$ per 1000 batteries manufactured. Table 7-5 summarizes the process solid wastes generated at various-sized lead-acid battery manufacturing facilities.

TABLE 7-5. ESTIMATED DAILY PROCESS SOLID WASTES GENERATED AT LEAD-ACID BATTERY MANUFACTURING FACILITIES

	Plant size, bpd		
Type of waste	500	2000	6500
Sludge (lime treatment), Mg (tons)	6.5 (7.5)	26 (30)	84.5 (97.5)
Sludge (caustic soda treatment), kg (lb)	5.5 (12)	22 (48)	73 (160)
$Pb(OH)_2$, kg (lb)	1.3 (2.8)	5.0 (11.2)	16.5 (36.4)
$PbSO_4$, kg (lb)	2.6 (5.8)	10.6 (23.4)	34.5 (76.1)

7.3.3 Incremental Solid Waste Impact

The increase in solid waste production due to increase emissions control will be slight. The largest increase is in sludge generated by lime treatment of the blowdown from the formation facility control system. Smaller increases are due to collection of air pollutants at the power plant that generates electricity to power the battery plant's control devices.

The amount of sludge produced at the lime wastewater treatment facility is proportional to the amount of sulfuric acid neutralized. Most plants can reuse the acid collected by mist eliminators used to control emissions from the formation process. If the acid mist is diluted or contaminated, however, it must be discharged through the waste treatment system. An addition of 94 kg/day (208 lb/day) of acid mist from a wet collector controlling the formation operation at a 6500 bpd plant will produce an additional 14.5 kg (32 lb) of sludge per day. Therefore, the increase in solid waste expected from waste treatment sludge is only 0.15 percent.

Wastewater streams from other air pollution control devices will not increase the volume or change the composition of the sludge. Also, sludge production will be insignificant at a 6500 bpd plant that uses caustic to treat effluents from the formation process.

The solid wastes from dry collection of lead air pollutants are sent to in-plant or outside reclamation furnaces or smelters for lead recovery. These wastes are collected at the rate of 13.4 to 25 kg (29.6 to 54.8 lb) of lead per 1000 batteries produced, depending upon the control alternative applied.

Additional solid wastes resulting from generation of electricity for the control systems can be as much as 9.1 Mg (10 tons) per year for a coal-burning plant with sulfur oxides controls.

Table 7-6 summarizes the maximum solid waste impacts due to the NSPS. These figures are based on a battery plant using control alternative

I (see Table 6-2) and served by a coal-fired utility. The data indicate that solid waste production will not increase by more than 0.5 percent.

TABLE 7-6. POTENTIAL SOLID WASTE IMPACTS OF A BATTERY PLANT USING CONTROL ALTERNATIVE I

Quantity
Mg/yr per 1000 bpd
(TPY/1000 bpd) capacity

Source	Uncontrolled	Increase with controls	Disposition
Waste treatment (lime)	3360 (3700)	5.0 (5.5)	landfill
Air pollution control (fabric filter)	0	6.3 (6.9)	recovery
Power plant	0	4.5 (5.0)	landfill
Total	3360 (3700)	15.8 (17.4)	

7.4 ENERGY IMPACTS

Any of the alternative control systems installed to comply with a new source performance standard will require electricity. The major portion of the electrical energy is needed to operate the fans installed to overcome the pressure drop across the control systems. Lesser amounts of electrical energy are needed for motors that operate the pumps in scrubber control devices and the shaking mechanisms in fabric filters. The additional fan energy requirements for the control systems described in Chapter 6.0 are reitterated (from section 7.1.3) below:

Plant Size (bpd)	Power Requirements (MWhr/yr)	
	Lead Controls	Acid Mist Controls
100	17	7.5
250	17	7.5
500	28	9.6
2000	80	40
6500	252	129

These requirements are based on pressure drops of 1245 kPa (5 in. W.G.) for lead emission control equipment, and 620 kPa (2.5 in. W.G.) for reclaimation emission controls are not included since existing state regulations (SIP's) require control of these emissions. Also, energy requirements to overcome duct pressure drops are not included, since ducting to ventialte process exhausts is required to meet OSHA standards. Finally, the above figures do not include energy requirements of lead oxide manufacture emission controls, because such controls are required for product recovery.

Tables 7-7 and 7-7A compare the eneagy requirements (in terms of cal's and Btu's respectively) for 100, 250, 500, 2000, 6500 bpd plants for the four following entities: process; exhaust; SIP control; NSPS lead control; and NSPS acid mist control. Process energy demands are based on reported total plant energy requirements of various sized battery plants less estimated energy requirements for exhaust, SIP control, and NSPS control. Exhaust energy demands were estimated using typical exhaust rates and assuming an average 620 kPa (2.5 in. W.G.) ductwork pressure drop for all process exhaust streams. Energy demands for SIP control are based on a 1245 kPa (5 in. W.G.) pressure drop. Energy requirements for product recovery equipment for lead oxide manufacturing processes are considered process energy. Finally, all demands for electrical energy (fan requirements) are expressed in terms of the amount of thermal energy required to generate the needed electricity (assuming a power plant efficiency of 34 percent).

Projections for 1985 lead-acid battery industry-wide energy usage were made by assuming that energy demands will increase at the same rate as

TABLE 7-7. ENERGY REQUIREMENTS FOR LEAD ACID BATTERY MANUFACTURING PLANTS AND EMISSION CONTROL EQUIPMENT (METRIC UNITS)

Plant size, bpd	Manufacturing processes		Process and plant exhaust		SIP controls		NSPS Lead controls[a]		NSPS Acid Mist controls	
	Gcal/yr	Equivalent oil, kl/yr	Gcal/yr	Equivalent oil, kl/yr	Gcal/yr	Equivalent oil, kl/yr	Gcal/yr	Equivalent oil, kl/yr	Gcal/yr	Equivalent oil, kl/yr
100	1,680	167	45.2	4.55	4.1	0.41	43	4.73	19.0	2.09
250	4,200	416	45.2	4.55	4.1	0.41	43	4.73	19.0	2.09
500	8,400	833	63.4	6.36	33.0	3.29	69.9	7.10	24.0	2.44
2000	13.200	1,310	193	19.1	81.2	7.95	203	20.1	101	10.1
6500	27,900	2,780	584	58.3	198	19.6	638	32.3	326	32.3

[a] Excludes energy required for SIP controls.

TABLE 7-7A. ENERGY REQUIREMENTS FOR LEAD ACID BATTERY MANUFACTURING PLANTS AND EMISSION CONTROL EQUIPMENT (ENGLISH UNITS)

Plant size, bpd	Manufacturing processes		Process and plant exhaust		SIP controls		NSPS Lead controls[a]		NSPS Acid Mist controls	
	10^9 Btu/yr	Equivalent oil, 1000 ga/yr	10^9 Btu/yr	Equivalent oil, 1000 gal/yr	10^9 Btu/yr	Equivalent oil, 1000 gal/yr	10^9 Btu/yr	Equivalent oil, 1000 gal/yr	10^9 Btu/yr	Equivalent oil, 1000 gal/yr
100	6.6	180	0.18	1.20	0.02	0.11	0.18	1.25	0.08	0.55
250	16.5	190	0.18	1.20	0.02	0.11	0.18	1.25	0.08	0.55
500	33	220	0.25	1.68	0.13	0.87	0.24	1.66	0.13	0.86
2000	52	347	0.76	5.04	0.32	2.10	0.80	5.32	0.40	2.66
6500	110	734	2.30	15.4	0.78	5.18	2.5	16.7	1.3	8.53

[a] Excludes energy required for SIP controls.

industry manufacturing capacity (i.e., 40 percent from 1975 to 1985). This would mean that the 1975 estimated industry energy requirements 1.2 Pcal/yr (4.8 trillion Btu/yr) or 0.21 Tg or coal or 0.12 Gl of residual oil (0.23 million tons of coal or 0.76 million barrels of residual oil) will increase to 1.7 Pcal/yr (6.7 trillion Btu/yr) by 1985. Energy which would be required to meet New Source Performance Standards represents about 3.2 percent of this figure, or 52 Tcal/yr (210 million Btu/yr). Approximately 35 Tcal/yr (140 million Btu/yr would be needed to control lead emissions while 17 Tcal/yr (70 million Btu/yr) would be needed to control acid mist emissions. Note that each control alternative has the same energy demand and the various control alternatives do not effect makeup air. The NSPS energy requirements are in addition to energy demands for the process exhaust and SIP control.

7.5 OTHER ENVIRONMENTAL IMPACTS

Application of a control system could cause no significant increase in noise, heat, or static electrical energy. None of the eight plants visited in this study reported problems regarding these environmental hazards.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

Increased emission control of the battery industry would result in a trade off of environmental gains at the expense of energy losses. All the control devices required to bring battery manufacturing facilities into compliance with increased emissions control requirements must be powered by electrical energy. These power requirements result in an irretrievable commitment of coal, oil, natural gas, or nuclear fuel as an energy source for power plants. Section 7.4 discusses the energy penalties associated with lead-acid battery plant control strategies.

7.6.2 Environmental Impact of Delayed Standards

Delay in setting of standards will allow the construction of new battery facilities without controls. Manufacturers may, however, in anticipation of SIP regulations for lead, install control equipment on both new and existing facilities.

At present, most state regulations do not specifically regulate lead-acid battery facilities. A few states have standards regulating lead-bearing particulates from secondary nonferrous operations. Other states have ambient air standards for sulfuric acid, and one state specifically limits emissions of sulfuric acid from the stack.[20] Concentrations of sulfuric acid in formation exhausts are too low to require controls under the regulations of that state.

A delay of one year in the adoption of the NSPS will result in the nationwide emission of approximately 4 Mg (4.4 tons) of lead over and above that permitted by anticipated SIP regulations.

A delay in promulgation of a New Source Performance Standard for sulfuric acid mist may cause only a slight increase in uncontrolled acid mist emissions, since many new installations tend to control exhausts from dry formation processes.

7.6.3 Environmental Impact of No Standard

As mentioned earlier, most states do not now regulate emissions of lead or sulfuric acid from lead-acid battery manufacturing facilities. In the absence of SIP regulations, "no standard" would cause lead and sulfuric acid mist emissions from these plants to increase as lead-acid battery production increases. Also, the increased process venting requirements, due to the recently established OSHA lead-in-air standard of 50 $\mu g/m^3$, may increase lead emissions to the atmosphere. However, with the promulgation of a lead ambient air quality standard, the increase in lead emissions would be less severe.

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8.0 ECONOMIC IMPACTS

8.1 INDUSTRY ECONOMIC PROFILE

8.1.1 Introduction

The lead-acid storage battery industry is the largest single consumer of lead in the United States. In 1977, the industry accounted for approximately 945,000 short tons of lead, which is 59.7 percent of the total 1,582,000 short tons of lead consumed domestically.[1] Total U.S. lead supplies in 1977 originated from imports (14.4%), secondary production (44.7%), refinery production (32.8%) and inventory (8.0%).[2]

Traditionally, lead-acid batteries account for 90 percent of total storage battery sales. Because of the flourishing activity in the U.S., some foreign concerns are attempting to penetrate the market. Britain's Chloride group and France's SAFT have purchased a few small U.S. battery makers, and Germany's leading battery producer, Varta AG, is moving into Canada and looking toward entrance into the U.S. market.

8.1.2 Number, Size of Plants and Regional Distribution

The industry in this country is dominated by six companies. Table 8.2 indicates that these six manufacturers hold over 70 percent of the market, the top four accounting for 60 percent of industry sales.[3,4]

There are approximately 190 lead-acid battery plants in

Table 8.1

CONSUMPTION OF LEAD IN THE UNITED STATES

BY PRODUCT[1]

(in thousand short tons)

1977

	Amount	Percentage
Metal Products		
Ammunition	68.3	4.3%
Brass and Bronze	16.7	1.1
Cable Covering	15.1	1.0
Sheet Lead	16.7	1.1
Solder	64.3	4.1
Storage Battery Grids, etc.	459.3	29.0
Storage Battery Oxide	486.5	30.8
Other	59.1	3.7
Pigments		
White Lead	6.6	.4
Red Lead and Litharge	78.0	4.9
Pigment Colors	14.7	.9
Other	.6	.04
Chemicals		
Gasoline Antiknock Additives	232.9	14.7
Miscellaneous Chemicals	.1	-
Miscellaneous Uses		
Annealing	2.7	.2
Galvanizing	1.4	.09
Lead-plating	.5	.03
Weights and Ballast	19.1	1.2
Other Uses Unclassified	39.5	2.5
Total	1,582.1	100.0*

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*Does not add to 100 because of rounding.

Table 8.2

LEADING DOMESTIC STORAGE BATTERY MANUFACTURERS[3]

Parent Co./Address	Branch Plant Location	Estimated 1974 sales million, $	Share of U.S. Market %
ESB, Inc. Philadelphia, Pa.	Los Angeles, Calif. Milipitas, Calif. Woodland, Calif. Denver, Colo. Fairfield, Conn. Atlanta, Ga. Warsaw, Ill. Logansport, Ind. Burlington, Iowa Minneapolis, Minn. Kansas City, Mo. Omaha, Neb. Buffalo, N.Y. Cheektowaga, N.Y. Raleigh, N.C. (2 plants) Allentown, Pa. Philadelphia, Pa. Sumter, S.C. Memphis, Tenn. Dallas, Tex. Racine, Wisc.	241.3	21.0
General Motors Corp. Delco-Remy Div. Detroit, Mich.	Anaheim, Calif. Muncie, Ind. Olathe, Kan. New Brunswick, N.J. Fitzgerald, Ga.	204.6	17.8
Gould, Inc. Chicago, Ill.	City of Industry, Cal. Orlando, Fla. Kankakee, Ill. Leavenworth, Kan. Howell, Mo. St. Paul, Minn. (3 locations) Trenton, N.J. Zanesville, Ohio Salem, Ore. Memphis, Tenn. Dallas, Tex. Lynchburg, Va.	151.1	13.1

Table 8.2 Continued

Parent Co./Address	Branch Plant Location	Estimated 1974 sales million, $	Share of U.S. Market %
Globe-Union, Inc. Milwaukee, Wisc.	Fullerton, Calif. Middletown, Del. Tampa, Fla. St. Joe, Mo. Atlanta, Ga. Geneva, Ill. Louisville, Ky. Owosso, Mo. Oregon City, Ore. Candy, Ore. Garland, Tex. N. Bennington, Vt.	82.0	7.4
Northwest Industries, Inc. General Battery Div. Chicago, Ill.	Selma, Ala. Stratford, Conn. Salina, Kansas Frankfort, Ind. Portland, Ore. Reading, Pa. Toledo, Ohio Greer, S.C. Dallas, Tex. Hamburg, Pa. Laureldale, Pa.	78.5	6.8
Eltra Corp. New York, N.Y.	Attica, Ind. Brookston, Ind. Vincennes, Ind. Oklahoma City, Okla. Reading, Pa. Laureldale, Pa. Temple, Pa. East Point, Ga. Manchester, Iowa	62.1	5.4

the U.S., of which about 91 have been estimated to be small plants* (less than 500 bpd).[5] These 190 plants are scattered throughout the country and are generally located in highly urbanized areas near the market for their batteries. Figure 8-1 shows the regional distribution of these 190 plants.

Of the approximately 91 small plants, 31 are classified as assemblers. As will be considered in section 8.4.4, assemblers purchase all of the materials and parts that are required for a battery and assemble these parts into a finished battery. They generally perform all of the functions of the small manufacturer except grid casting and pasting. The impact of the sulfuric acid mist control and lead NSPS control cost on these small manufacturers and assemblers will be shown in section 8.4.4.

Small manufacturers and assemblers are generally one-plant operations, though some manufacturers and assemblers may have warehouse space in locations other than their plant. Therefore, for the 91 small plants there are approximately 91 firms. Direct delivery to client accounts is generally the rule as this is a most profitable distribution pattern for the plants.

As was seen in section 3.5, battery manufacturing can be distinguished by the formation process - wet or dry formation. No information is available on the number of plants forming wet versus dry or a combination of wet/dry. The

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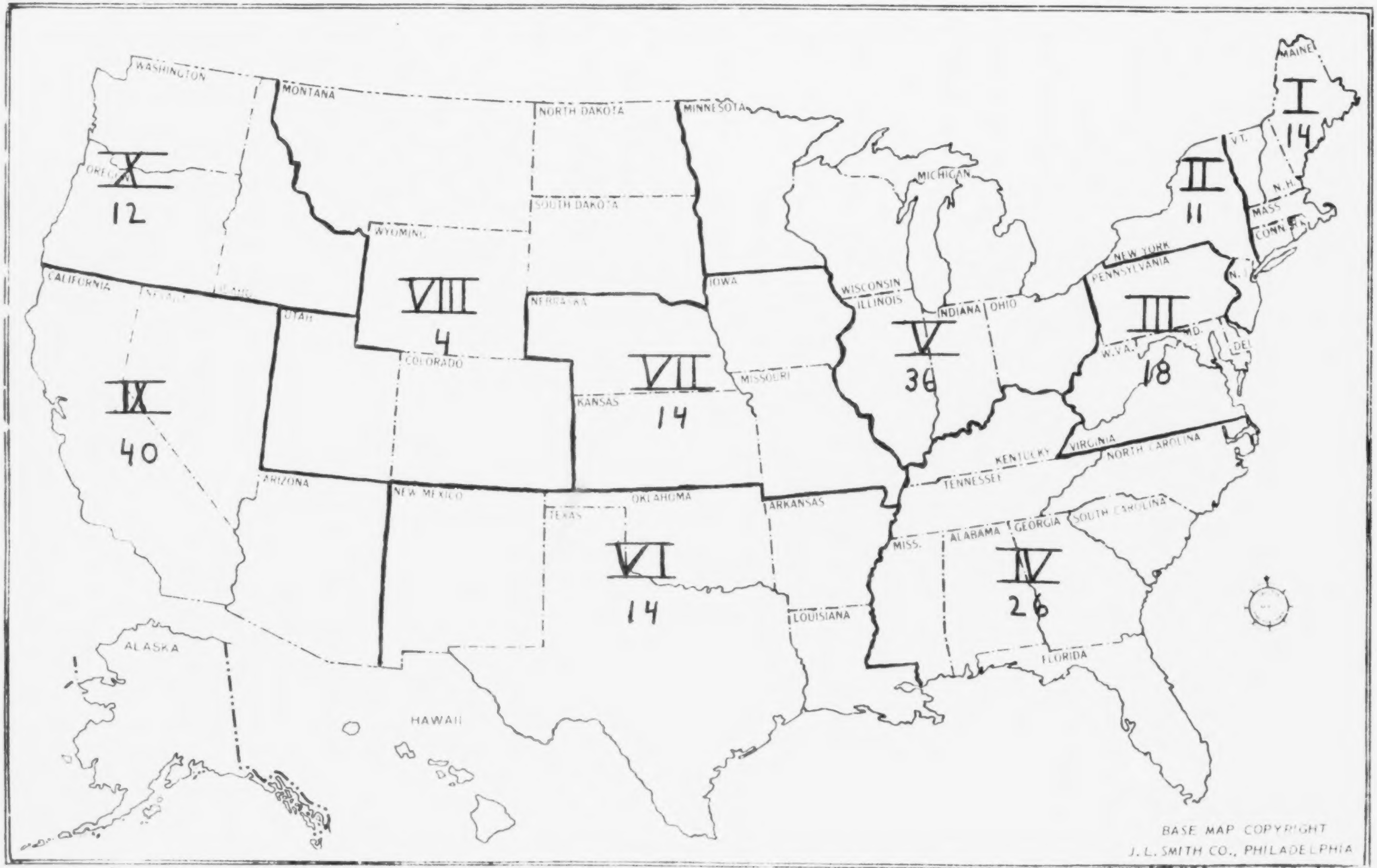
*Excluding small plants of the larger multiplant companies.

Figure 8-1

REGIONAL DISTRIBUTION OF LEAD-ACID BATTERY PLANTS

EPA REGIONS


I
14
II
11
III
18
IV
26
V
36
VI
14
VII
14
VIII
4
IX
40
X
12
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISS.
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W.VA.
MD.
DEL
N.J.
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Region II - includes Puerto Rico and Virgin Island
Region IX - includes Hawaii
Region X - includes Alaska

large plants probably have dry formation capability if they are selling to retail markets, since dry forming increases the shelf life of a battery. Small plants generally specialize in wet formation; if any dry formation is performed, it is usually a small portion of their total battery production.

Employment in the industry is approximately 19,000 people.[6] Since a 500 BPD plant would generally employ 20-25 people and a 100 BPD plant about 5 or 6 people, small plant employment accounts for about 1300 of the total, based on an average of 15 people per small plant.

8.1.3 Markets

The market for lead-acid storage batteries is composed of two segments. The first and largest segment consists of replacement batteries for automobiles, trucks and buses, heavy equipment, recreational vehicles, farm machinery, and other vehicles. The replacement market accounted for 78.8 percent of industry sales in 1977. The second largest market, holding 21.2 percent of sales, is the original equipment market, consisting of batteries sold to producers of new cars, new trucks, and other new products. Table 8-3 summarizes shipments to these markets for the past 10 years.

The industry as a whole has enjoyed an average growth rate of 4.9 percent per year between 1968 and 1977. In 1974 and 1975 the economic recession caused a slowdown in sales and production of new vehicles and therefore in battery sales.

Except for a decline in 1975, replacement battery shipments

Table 8.3

BATTERY SHIPMENTS BY DOMESTIC PRODUCERS[7]

Year	Replacement Batteries		Original Equipment		Exports		Total Units, (thousands)
	Units, (thousands)	Share of Market, %	Units, (thousands)	Share of Market, %	Units, (thousands)	Share of Market, %	
1968	33793	75.2	10718	23.8	456	1.0	44967
1969	35510	76.5	10147	21.9	760	1.6	46417
1970	37863	80.7	8239	17.6	819	1.7	46921
1971	39143	77.2	10673	21.0	928	1.8	50708
1972	43220	77.9	11270	20.3	983	1.8	55473
1973	43453	76.1	12637	22.1	1017	1.8	57107
1974	44408	81.5	10058	18.5	a	a	54466[b]
1975	42582	82.5	8985	17.5	a	a	51567[b]
1976	49203	78.6	13365	21.4	a	a	62568[b]
1977	54601	78.7	14718	21.3	a	a	69319[b]

[a] Export figures not available.

[b] Does not include exports.

have increased each year of this 10-year span at an average rate of 5.5 percent a year. Original equipment battery shipments have been volatile but have increased at an average rate of 3.6 percent per year.

According to Globe-Union, the replacement market will continue to be strong. With more than 50 million vehicles entering the automobile aftermarket by 1990, the number of battery units should reach more than 285 million. Replacement battery shipments should reach 62.5 to 63.5 million units in 1982, an increase of approximately 25 percent over the 1977 level. Table 8-4 shows a forecast for replacement battery shipments for the years 1978 to 1982. Growth areas for the industry lie in trucks and commercial vehicles, both for original equipment and replacement batteries. Another source with potential for further market penetration lies in recreational vehicles, such as motorcycles, snowmobiles, golf carts, and motor boats. Globe-Union reports that this market accounted for $50 million in sales in 1970, and estimates that by 1985 the recreational market may account for over $200 million.[8]

Table 8.4

REPLACEMENT BATTERY SHIPMENTS[9]

(In Millions)

Year	Number of Units	Percent Change From Previous Year
1978	57.3	-
1979	58.3	1.7%
1980	57.7	-1.1
1981	59.2	2.6
1982	63.0	6.4

8.1.4 Distribution

Distribution of batteries by any plant usually takes place in a limited geographical area. Because the weight of lead-acid storage batteries is high relative to shipment value, transportation cost is high and significant cost savings accrue from geographical location adjacent to markets. It is generally economically inefficient to ship beyond a 250 to 300 mile radius. If a company wants national distribution of its product, plants have to be located in regional markets. Proximity to markets appears to be a key to the economic viability of many small producers, whose unit manufacturing costs and F.O.B. plant prices are significantly higher than those of larger companies.

The large producers are distributing primarily to the large original equipment markets (OEM) such as the automobile companies, and large retail accounts such as Sears, Roebuck, and Co. and J.C. Penney. Warehouse distribution of their batteries to smaller accounts is also made. Smaller firms sell primarily to fleet accounts such as local cab companies, government and business firms, local gas stations, discount stores, and the like.

The marketing chain for batteries is primarily from battery producer to warehouse to jobber to retailer, although individual links in the chain are often bypassed. This is particularly true of the smaller producer who is selling to fleet accounts. Deliveries to these accounts are made in company-owned trucks because it is more profitable to deliver directly.

In this way the small firm can accrue the markup which would have been applied by the intermediaries to the final buyer. These markups vary by 20 to 65% from the warehouse price depending on the client account.[10]

Competition between the large and small producer for some client accounts exists through local warehouse distribution of the larger company's battery to clients in the smaller producer's market. The smaller producer, however, offers additional services such as faster delivery time, personalized service, better credit arrangements, and pick-up of small quantities of junk batteries from customers.

No alternative source can provide energy for a cost comparable to that provided by the lead-acid storage battery in its automobile application. This cost efficiency tends to be true for other uses of SLI batteries such as golf carts and snowmobiles. Potential substitutes, such as the nickel-cadmium, nickel-zinc, nickel-iron, silver-zinc and silver-cadmium batteries, cost from three to five times as much as lead-acid batteries.

8.1.5 Imports

Imports and exports of storage batteries are, in general, associated with the imports and exports of automobiles. The high transport costs associated with storage batteries make competitive pressure from foreign manufacturers a neglibile factor in response to battery price movements.

8.2 COST ANALYSIS OF ALTERNATIVE CONTROL SYSTEMS

The approach to determining the costs associated with the alternative control systems involved three steps: 1) selecting five representative model plants; 2) applying the selected five control alternatives for lead and the sulfuric acid mist control system as discussed in Chapter 6; and 3) determining the total control costs based upon each strategy and typical exhaust volumes. This three-step procedure is applied to both new and modified plants. The results of this analysis are used in determining economic impacts of the alternative systems in Section 8.4. (The listing of eight control alternatives, as shown in Table 6-2, is repeated for convenient reference as Table 8-6).

Of the approximately 200 battery manufacturing plants in the United States, nearly 50 percent manufacture less than 500 units per day and 30 percent manufacture between 500 and 6500 units per day.* Based on these statistics, the following model plant sizes were selected: small - 100, 250, and 500 bpd; medium - 2000 bpd; and large - 6500 bpd. Typical parameters for uncontrolled exhaust from the facilities within these model plants are given in Tables 8-7 and 8-7A. These parameters were estimated from data obtained from plant representatives, design calculations, and various reports of source tests.

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* Based on employment data obtained from Reference 25 and assuming output at 25 batteries per man-day.

Table 8-6. SELECTED CONTROL ALTERNATIVES FOR LEAD-ACID BATTERY MANUFACTURING INDUSTRY

Control alternative	Facilities[a]	Control system[b]
I	A, B, F	Fabric filter, 6/1 A/C
	C, E	Fabric filter, 6/1 A/C
	G	Mist eliminator
	D	Fabric filter, 2/1 A/C
II	B, C, E	Fabric filter, 6/1 A/C
	F	Impingement and entrainment scrubber
	A	Impingement and entrainment scrubber
	G	Mist eliminator
	D	Fabric filter, 2/1 A/C[c]
III	C, E	Fabric filter, 6/1 A/C
	A, B, F	Impingement and entrainment scrubber
	G	Mist eliminator
	D	Fabric filter, 2/1 A/C
IV	A, B, C	Impingement and entrainment scrubber
	E	Fabric filter 6/1 A/C
	F	Impingement and entrainment scrubber
	G	Mist eliminator
	D	Fabric filter, 2/1 A/C[c]
V	A, B, C, F	Impingement and entrainment scrubber
	E	Fabric filter, 6/1 A/C
	G	Mist eliminator
	D	Fabric filter, 2/1 A/C[c]
VI	A, B, C	Fabric filter, 6/1 A/C
	E	Fabric filter, 6/1 A/C
	G	Mist eliminator
VII	A, B, C, E	Fabric filter, 6/1 A/C
	G	Mist eliminator
VIII	A, B, C	Impingement and entrainment scrubber
	E	Fabric filter, 6/1 A/C
	G	Mist eliminator

[a] Facilities key: A - Grid casting furnace; B - Grid casting machines; C - Paste mixer; D - Lead oxide manufacturing; E - Three process operation and assembly; F - Lead reclaim furnace; G - Formation.

[b] All facilities are vented to common control systems as shown.

[c] Small ($\leq$ 500 bpd) plants are assumed to have no PbO manufacturing facilities.

Table 8-7. TYPICAL UNCONTROLLED EXHAUST PARAMETERS FOR BATTERY MANUFACTURING FACILITIES[a] (METRIC UNITS)

Facility code letter	Facility	Temperature, °C	Moisture, %	Total particulate loading, mg/m^3	Volume by plant size, m^3/min				
					100 bpd	250 bpd	500 bpd	2000 bpd	6500 bpd
A	Grid casting furnace[b]	115	2-3	<23	27.5	27.5	33.7	57.0	127
B	Grid casting machine[b]	38	2-3	<23	27.5	27.5	33.7	57.0	127
C	Paste mixer	38	2-4	137	62.0	62.0	67.9	89.5	154
D	Lead oxide manufacturing	115	2-3	21[d]	c	c	c	87.2	216
E	Three-process operation	27	1-2	46	403	403	472	733	1517
F	Lead reclaim furnace	115	2-3	>229	f	f	198	198	198
[illegible]	Formation	27	N.A.	4000[e]	75.3	177	347	1366	4020

[a] Based on exhaust data obtained from industry responses to EPA's inquiries (Section 114 Letters), design calculations and source test reports.

[b] The grid casting facility consists of a furnace and a machine. Sometimes these elements are separate, as where one furnace feeds many casting machines.

[c] For purposes of this study, it is assumed that plants making only 500 bpd or less have no PbO manufacturing facilities.

[d] Measured at outlet of baghouse, which is part of the process.

[e] Test data from outlet of fan separator tested at Plant G indicated <10 ppm H_2SO_4 (<38.9 mg/m^3); assuming control device was 99 percent efficient, uncontrolled emission approximates 4000 mg/m^3.

[f] It is assumed for the purposes of this study that plants making <500 bpd have no lead reclaim furnace.

Table 8-7A. TYPICAL UNCONTROLLED EXHAUST PARAMETERS FOR BATTERY MANUFACTURING FACILITIES[a] (ENGLISH UNITS)

Facility code letter	Facility	Temperature, °F	Moisture, %	Total particulate loading, gr/dscf	Volume by plant size, acfm				
					100 bpd	250 bpd	500 bpd	2000 bpd	6500 bpd
A	Grid casting furnace[b]	240	2-3	<0.01	970	1050	1190	2015	4470
B	Grid casting machine[b]	100	2-3	<0.01	970	1050	1190	2015	4470
C	Paste mixer	100	2-4	0.06	2190	2270	2400	3160	5460
D	Lead oxide manufacturing	240	2-3	0.009[d]	c	c	c	3080	7630
E	Three-process operation	80	1-2	0.02	14220	15140	16680	25900	53600
F	Lead reclaim furnace	240	2-3	>0.10	f	f	7,000	7,000	7,000
G	Formation	80	N.A.	1.6[e]	2660	6260	12260	48300	142000

[a] Based on exhaust data obtained from industry responses to EPA's inquiries (Section 114 Letters), design calculations and source test reports.

[b] The grid casting facility consists of a furnace and a machine. Sometimes these elements are separate, as where one furnace feeds many casting machines.

[c] For purposes of this study, it is assumed that plants making only 500 bpd or less have no PbO manufacturing facilities.

[d] Measured at outlet of baghouse, which is part of the process.

[e] Test data from outlet of fan separator tested at Plant G indicated <10 ppm H_2SO_4 (<0.017 gr/dscf); assuming control device was 99 percent efficient, uncontrolled emission approximates 1.6 gr/dscf.

[f] For purposes of this study, it is assumed that plants making less than 500 batteries per day have no lead reclaim furnace.

Uncontrolled lead emissions based on data obtained from tests performed in this study are shown in Table 8-8. Typical uncontrolled emissions of lead from the grid-casting, three-process operation, and lead oxide manufacturing facilities are less than 0.5 kg/metric ton (1 lb/ton) of process weight. At a production rate of 200 batteries per hour (approximately 3.6 Mg/hr [8,000 lb/hr] process weight rate) uncontrolled lead emissions from the three-process operation would approximate 1.3 kg/hr (2.9 lb/hr). If it is assumed that lead represents only 50 percent of the total particulate emissions,[**] this facility would still comply with a typical process weight rate regulation (for particulate matter) as set forth in a State Implementation Plan (SIP) because of its high process weight rate. Similarly, the grid casting and lead oxide manufacturing facilities would comply with this regulation.

[**] Tests made during this study measured only lead. Other contaminants such as bits of material from separators, cork from the mold release agent, and the like must be considered. It is estimated that the lead constitutes at least 50 percent of the total particulate matter.

Table 8-8. UNCONTROLLED LEAD EMISSIONS FROM VARIOUS LEAD-ACID BATTERY MANUFACTURING FACILITIES[a]

Facility	Emissions
Grid casting	0.4 kg/1000 (0.9 lb/1000) batteries[b]
Paste mixing	5.1 kg/1000 (11.2 lb/1000) batteries[b]
Three-process operation	6.6 kg/1000 (14.7 lb/1000) batteries[b]
PbO manufacturing	0.01 kg/Mg (0.02 lb/ton) of lead throughput
Reclamation	3.0 kg/Mg (5.9 lb/ton) of lead charged

[a] Based on data obtained from source tests performed in this study.

[b] For estimating purposes, each battery weighs 18 kg (40 lb) and contains 12 kg (26 lb) of lead, of which approximately half is in the paste and half is in the cast parts.

The paste mixing and lead reclamation facilities apparently would not comply with such a regulation, and therefore controls would be required for these facilities even without the promulgation of a New Source Performance Standard.*

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* The possible effects of future SIP regulations for lead are not considered in this chapter.

Very few SIP's regulate sulfuric acid mist emissions from the formation facility. New Jersey has set a limit of 10 mg/scf. A spokesman for the New Jersey Air Pollution Control Agency states that the plant in his jurisdiction complies with both this regulation and New Jersey's particulate matter regulation without use of a control device.[11]

8.2.1 New Facilities

8.2.1.1 Capital Cost of Control Systems - Control equipment costs are shown in Tables 8-9 and 8-9A. All costs in this section are based on 4th-quarter 1977 dollars. This equipment represents the most efficient from a pollutant control viewpoint and is currently used only on the best-controlled facilities. Costs were obtained directly from vendors and updated to 4th-quarter 1977 using the Marshall and Swift Index.[12,13]

Two major categories of costs have been developed: installed capital costs and total annualized costs. The installed capital cost for each control device system includes the purchased cost of the major and auxiliary equipment, cost of site preparation and equipment installation, and design engineering cost. Because of the short installation times required for construction of these control systems, no construction interest charges are included. No attempt is made to include costs of research and develop-

Table 8-9 AIR POLLUTION CONTROL EQUIPMENT COSTS FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES (METRIC UNITS)

Equipment type	Sized, m^3/min	Exhaust gas parameters			Cost,[a] F.O.B. site
		Temperature, °C	Moisture, %	Particulate loadings, mg/m^3	
Impingement and entrainment scrubber	28	27-115	1-4	46-137	$ 7,200
	425	27-115	1-4	46-137	20,000
Fabric filter, (pulse-jet with 6/1 A/C ratio)	142	27	1-4	46-137	10,500
	1982	27	1-4	46-137	100,600
Fabric filter, (shaker-type with 2/1 A/C ratio)	40	115	2-3	114-229	6,900
	125	115	2-3	114-229	12,100
Fabric filter, (shaker-type with 3/1 A/C ratio)	40	115	2-3	114-229	5,600
	125	115	2-3	114-229	10,400
Mist eliminator	57	27	N.A.	3663	4,370[b]
	87	27	N.A.	3663	5,000
	142	27	N.A.	3663	5,600
	1982	27	N.A.	3663	53,300

[a] 4th-quarter. 1977 dollars; includes cost of fans, motors, drives, pumps, pump motors, sludge injector, walkways, and ladders as is appropriate. All costs obtained from Reference 29 except as otherwise noted and updated to 4th-quarter 1977.

[b] Reference 15. Costs were updated to 4th-quarter 1977.

Table 8-9A. AIR POLLUTION CONTROL EQUIPMENT COSTS FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES (ENGLISH UNITS)

Equipment Type	Size, scfm	Exhaust gas parameters			Cost,[a] F.O.B. site
		Temperature, °F	Moisture, %	Particulate loading, gr/dscf	
Impingement and entrainment scrubber	1,000 15,000	80-240 80-240	1-4 1-4	0.02-0.06 0.02-0.06	$ 7,200 20,000
Fabric filter, (pulse-jet with 6/1 A/C ratio)	5,000 70,000	80 80	1-4 1-4	0.02-0.06 0.02-0.06	10,500 100,600
Fabric filter, (shaker-type with 2/1 A/C ratio)	1,400 4,400	240 240	2-3 2-3	0.05-0.10 0.05-0.10	6,900 12,100
Fabric filter, (shaker-type with 3/1 A/C ratio)	1,400 4,400	240 240	2-3 2-3	0.05-0.10 0.05-0.10	5,600 10,400
Mist eliminator	2,000 3,000	80 80	N.A. N.A.	1.6 1.6	4,370[b] 5,000
	5,000 70,000	80 80	N.A. N.A.	1.6 1.6	5,600 53,300

[a] 4th-quarter. 1977 dollars; includes cost of fans, motors, drives, pumps, pump motors, sludge injector, walkways, and ladders as is appropriate. All costs obtained from Reference 29 except as otherwise noted and updated to 4th-quarter 1977.

[b] Reference 15. Costs were updated to 4th-quarter 1977.

ment, possible loss of production during equipment installation, or losses during start-up. All capital costs reflect 4th-quarter 1977 prices for equipment, installation materials, and installation labor. Tables 8-10 and 8-11 present the various capital cost factors for installation of fabric filters and wet collectors, respectively. These factors are based on published information[16] and engineering judgment. Application of these factors to the equipment costs produces the cost curves shown in Figures 8-2 and 8-3. These Figures also show control system costs as reported by Plants B, C, D, E, G, and H updated to 4th-quarter 1977 by use of the Marshall and Swift (M & S) equipment cost index.

8.2.1.2 Annualized Cost of Control Systems - The total annualized cost consists of three categories: direct operating cost, capital charges, and (where applicable) credit for dust recovery. The first category accounts for operating and maintenance costs, which include these items:

- Utilities, including electric power and process water
- Operating labor
- Maintenance and supplies
- Solid waste disposal

Since the material collected in the pollutant control system is toxic, it is sent to a smelter for lead recovery. The value of the recovered lead tends to offset the refining

Table 8-10. COMPONENT CAPITAL COST FACTORS FOR A FABRIC FILTER AS A FUNCTION OF EQUIPMENT COST, Q

Component	Direct costs	
	Material	Labor
Equipment	1.00Q	0.25Q
Ductwork	0.04Q	0.21Q
Instrumentation	0.04Q	0.006Q
Electrical	0.11Q	0.16Q
Foundations	0.03Q	0.05Q
Structural	0.03Q	0.05Q
Sitework	0.02Q	0.02Q
Painting	0.004Q	0.02Q
Total direct costs	1.27Q	0.77Q

Component	Indirect costs	
	Measure of costs	Factor
Engineering	10% material and labor	0.204Q
Contractor's fee	15% material and labor	0.306Q
Shakedown	5% material and labor	0.102Q
Spares	1% material	0.013Q
Freight	3% material	0.038Q
Taxes	3% material	0.038Q
Total indirect costs		0.696Q
Contingencies - 20% of direct and indirect costs		0.547Q
Total capital costs		3.28Q

Table 8-11. COMPONENT CAPITAL COST FACTORS FOR A WET COLLECTOR (SCRUBBER OR MIST ELIMINATOR) AS A FUNCTION OF EQUIPMENT COST, Q

Component	Direct costs	
	Material	Labor
Equipment	1.00Q	0.25Q
Ductwork	0.03Q	0.13Q
Instrumentation	0.04Q	0.006Q
Electrical	0.11Q	0.16Q
Foundations	0.03Q	0.05Q
Structural	0.03Q	0.05Q
Sitework	0.02Q	0.02Q
Painting	0.004Q	0.02Q
Piping	0.15Q	0.16Q
Total direct costs	1.41Q	0.85Q

Component	Indirect costs	
	Measure of costs	Factor
Engineering	10% material and labor	0.226Q
Contractor's fee	15% material and labor	0.339Q
Shakedown	5% material and labor	0.113Q
Spares	1% material	0.014Q
Freight	3% material	0.042Q
Taxes	3% material	0.042Q
Total indirect costs		0.776Q
Contingencies - 20% of direct and indirect costs,		0.607Q
Total capital costs		3.64Q

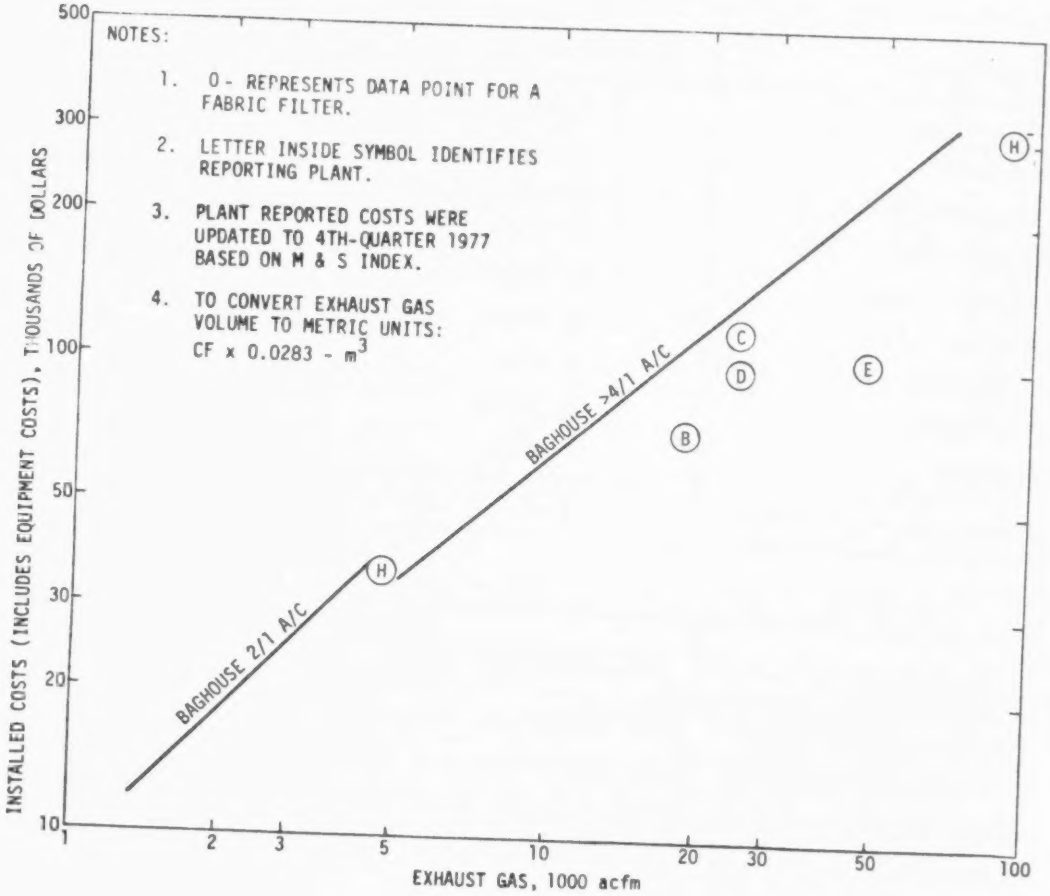

Figure 8-2. Reported installed costs of fabric filter control systems compared with estimated cost curves used in this study (4th-quarter 1977 dollars).

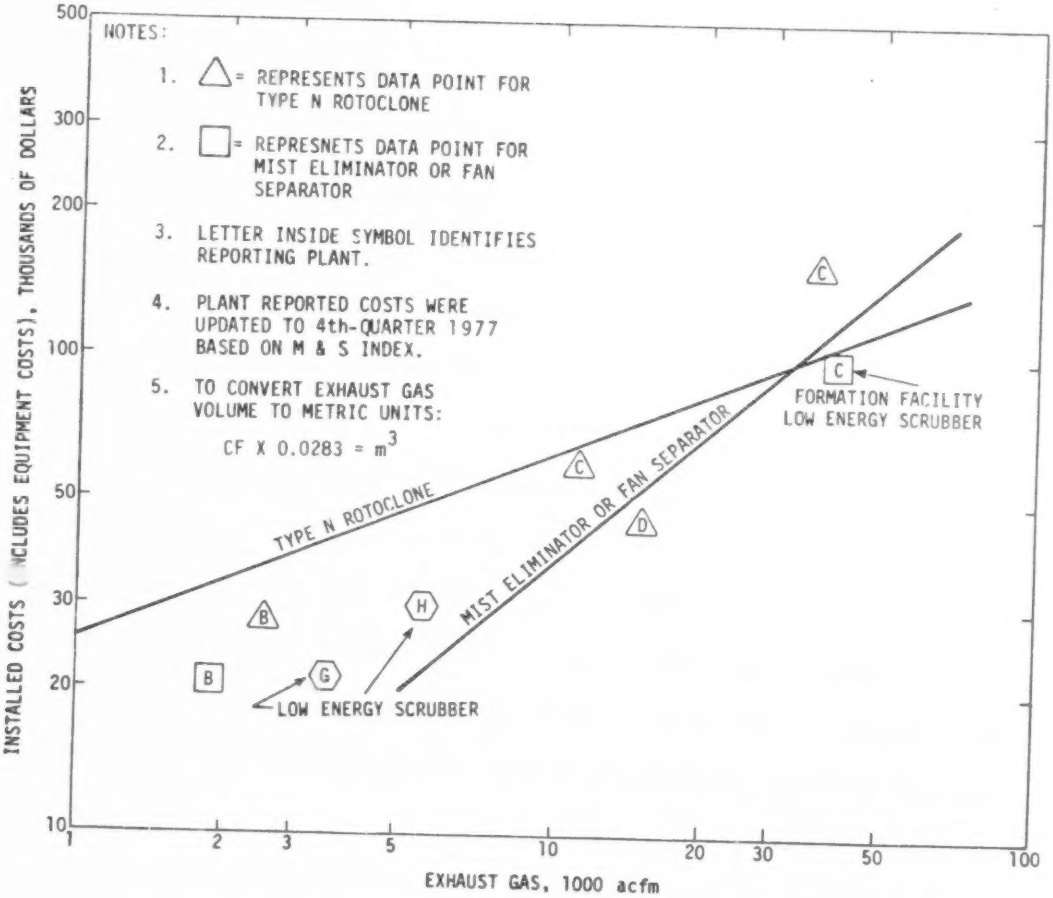

Figure 8-3. Reported installed costs of wet scrubber systems compared with estimated cost curves used in this study (4th-quarter 1977 dollars).

costs. Generally, no solid waste disposal costs due to air pollution control are incurred in the lead-acid battery industry. The industry therefore receives no dust recovery credit.[17,18]

Capital charges account for depreciation, interest, administrative overhead, property taxes, and insurance. Depreciation and interest are computed by use of a capital recovery factor (CRF), the value of which depends on the operating life of the device and on the interest rate. (An operating life of 15 years and an annual interest rate of 10 percent are assumed). Insurance cost is fixed at an additional 0.3 percent of the installed capital cost per year. Because most states have liberalized their tax laws regarding air pollution control equipment, the cost of taxes is considered to be negligible. The values used for overhead are shown in Table 8-12 and the various items and unit values used in computing total annualized costs are listed in Table 8-13.

Annualized costs of operation of control devices on all facilities except formation and lead oxide manufacturing are a function of the number of operating shifts per day. For purposes of this study, the following are designated: three shifts for a large plant, two shifts for a medium plant, and one shift for the small plants. The formation facility nor-

Table 8-12. ITEMS USED IN COMPUTING TOTAL ANNUALIZED COSTS

Item	Unit value
Operating factor	2000 hours/year/operating shift
Operating labor	$5/man-hour
Utilities	
Electric power	$0.03/kWh
Process water	$0.0625/m^3 ($0.25/thous. gal)
Solid waste disposal	0
Dust recovery credit	0
Capital recovery factor[a]	13.2% of installed capital cost

[a] For all air pollution control equipment; 15 year life, 10 percent interest assumed.

Table 8-13. CALCULATION OF ANNUALIZED COSTS OF AIR POLLUTION CONTROL SYSTEMS

Cost component	Method of calculation
Direct operating costs	
Utilities	
Water	Amount used per year x $\$0.0625/m^3$ ($0.25/1000 gal)
Electricity	Amount used per year x $0.03/kWh
Operating labor	
Direct	Number of manhours per year x $5.00
Supervision	15% of direct labor
Maintenance and supplies	
Labor and material	6% of total capital costs
Supplies	15% of labor and material
Capital charges	
Overhead	
Plant	50% of operating labor plus 50% of maintenance and supplies
Payroll	20% of operating labor
Fixed costs	
Capital Recovery	13.2% of total capital costs
Insurance	0.3% of total capital costs

mally operates 16 to 24 hours per day, regardless of plant size. For estimating purposes, it is assumed that this facility operates three shifts per day. Table 8-12 illustrates how annualized costs are computed for air pollution control systems used in the lead-acid battery manufacturing industry. Since all the dust or sludge collected in the control systems is sold to a lead smelter for a low price, the solid waste disposal cost and dust recovery credit are a tradeoff. The utilities and labor factors used in calculating the annualized costs are shown in Tables 8-14 and 8-14A. Smelters generally take waste only from customers and would refuse lead waste from noncustomers even if it were delivered to the smelter at no cost.[19]

8.2.1.3 Cost of Alternative Control Measures - Each of the ten model plants (five new, five retrofit) consists of from five to seven separate facilities (see Tables 3-7 and 8-7A). These facilities can each be controlled separately. In practice, these facilities are often controlled by common systems. Of the five selected alternative control systems for control of lead emissions from the larger plants, system I corresponds to best control technology for emission reduction considered; the other systems are presented for analysis of the cost aspects of various other levels of control. Control alternatives VI and VII represent the best control

Table 8-14. UTILITIES AND LABOR REQUIRED FOR OPERATION OF VARIOUS CONTROL DEVICES FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES (Metric Units)

Control	Pressure drop across device, Pa	Electric power requirements, kWh/hr/1000 m^3	Water usage m^3/1000 m^3	Operating factor, hr/yr	Direct labor, hr/yr
Fabric filter, 6/1 A/C	1245	20	0	2000-6000[a]	200-600[a]
Fabric filter, 2/1 A/C	0[b]	0[b]	0	0[b]	0[b]
Mist eliminator	249	4.2	67	6000	600
Impingement and entrainment scrubber	1245	20	134	2000-6000[a]	200-600[a]

[a] Depends on number of shifts/day device is operating; it is assumed that a small plant operates one shift; a medium plant, two shifts; a large plant, three shifts.

[b] This device is only used on the PbO manufacturing facility, which requires a fabric filter as part of the process. For estimating purposes, it is assumed that there is no significant difference between the utilities and labor required for the two systems.

Table 3-14A. UTILITIES AND LABOR REQUIRED FOR OPERATION OF VARIOUS CONTROL DEVICES FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES (English Units)

Control device	Pressure drop across device, in. W.G.	Electric power requirements, kWh/hr/1000 scfm	Water usage gal/1000 scfm	Operating factor, hr/yr	Direct labor, hr/yr
Fabric filter, 6/1 A/C	5	0.59	0	2000-6000[a]	200-600[a]
Fabric filter, 2/1 A/C	0[b]	0[b]	0	0[b]	0[b]
Mist eliminator	1	0.118	0.5	6000	600
Impingement and entrainment scrubber	5	0.59	1.0	2000-6000[a]	200-600[a]

[a] Depends on number of shifts/day device is operating; it is assumed that a small plant operates one shift; a medium plant, two shifts; a large plant, three shifts.

[b] This device is only used on the PbO manufacturing facility, which requires a fabric filter as part of the process. For estimating purposes, it is assumed that there is no significant difference between the utilities and labor required for the two systems.

technology for smaller plants. They differ only in configuration. The three alternatives, (VI, VII, and VIII) are considered for the cost aspects.

The control systems for which costs have been estimated are fabric filters, impingement and entrainment scrubbers, and mist eliminators, all of which are technically capable of achieving the various emission reductions. Each system includes all auxiliary equipment such as fans, motors, drives, pumps, sludge ejectors, walkways, and ladders, as is appropriate. It is necessary to provide insulation and auxiliary heating for fabric filters to which mixer gases are exhausted. However, this requirement depends on the geographic location of the baghouse, the exhaust gas' dew point, and the concentration of acid mist and water vapor. Those control alternatives in which the mixer gases are vented to a baghouse also vent the three process operation to the same device. This dilutes the mixer exhaust from a 6500 BPD plant by a 6 to 1 factor. In warm climates condensation may be controlled by installing the baghouse inside the building. The annualized cost of this precaution would be \$700, \$1100, and \$2400 for a 500 BPD, 2000 BPD, and 6500 BPD plants respectively, based on an annual space cost of \$3.50 per square foot. For purposes of this report, the cost of insulation and auxiliary heat sufficient to maintain a 55-65°C (130-150°F) exhaust gas temperature for condensation control was added. No allowance is made for handling and conveying systems for the collected sludge and dust. This material is normally manually dumped directly from the control device into reusable 0.2 cubic meter (55-gallon) drums or plastic bags and is shipped to a smelter. The estimated total particulate catch of an entire 6500 bpd plant is estimated at 158 kg (350 lb) per day. Shipment in plastic bags would require 10 bags per day, which can be purchased for approximately $4.00. This cost is insignificant relative to the estimated total annualized costs of more than $100,000.

For purposes of estimating the cost of the best demonstrated technology with regard to lead oxide manufacturing controls, it is assumed that the average facility incorporates a baghouse having an air-to-cloth ratio of 3 to 1 (3/1 A/C). This is part of the process equipment. To reach the collection efficiency of the control system tested at Plant G, it may be necessary to use fabric filters with an A/C of 2/1. Therefore the incremental cost of a 2/1 A/C baghouse is added to the overall control costs shown herein. None of the selected lead emissions control systems discharges water. Impingement and entrainment scrubbers generally use water at a rate of only 134 $m^3/1000$ m^3 (1 gpm/1000 acfm), only 20 percent of which is due to recirculation tank blowdown. The balance is lost through evaporation. This use results in a maximum increase of only 1 to 2 percent in total hydraulic flow for the plant (see Table 7-11). This increase would probably not require expansion of the water treatment system nor would it significantly increase the operating costs.

The mist eliminator used to control acid mist requires 67 m^3 water per 1000 m^3 (1/2 gpm per 1000 scfm). A typical battery plant requires 42 to 290 liters (11 to 74 gal) water per battery depending on whether batteries are wet- or dry-charged,[20] tne dry-charge battery requiring the higher amount. A typical plant requirement is given as an average of 250 liters/battery (66.5 gal/battery).[21] Thus the daily water flow to the plant's wastewater system is as follows:

Plant size, bpd	Manufacturing wastewater, m^3 (gal)/day	Water added for H_2SO_4 mist control, m^3 (gal)/day*
100	25 (6,600)	5 (1,200)
250	62 (16,500)	11 (2,900)
500	124 (33,000)	22 (5,800)
2000	503 (133,000)	87 (23,000)
6500	1627 (430,000)	260 (68,000)

The cost to build and operate the additional water treatment capacity must be added to the cost of the acid mist control. Based on the data reported in Reference 22 it is estimated that the additional capital costs and annualized costs for treatment of the mist eliminator water are as follows:

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* Based on 16 hrs. per day.

Plant size, bpd	Capital costs	Annualized costs
100, 250*	$ 300	$ 300
500	$ 1,000	$ 1,000
2000	$10,000	$ 6,000
6500	$15,000	$10,000

The estimated total costs of each control system for each control alternative are shown in Tables 8-15 through 8-22. Not all these costs are attributable to the promulgation of a New Source Performance Standard, since two facilities (lead reclamation and paste mixing) require controls just to meet typical SIP regulations for particulate matter. The applicable costs of these SIP controls must be deducted from the overall costs shown in Tables 8-15 through 8-22 SIP control costs are shown in Table 8-23. For estimating the SIP control costs, it is assumed that each facility is vented to a separate impingement and entrainment scrubber having a 90 percent total particulate collection efficiency.

Tables 8-24 through 8-28 show the net capital cost of lead control resulting from a New Source Performance Standard for lead. Table 8-29 lists the overall net capital

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* Capital costs and annualized costs are assumed to level off at the 250 BPD plant capacity level.

Table 8-15. COST OF EMISSION CONTROL SYSTEMS FOR CONTROL ALTERNATIVE I FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost, $1000
			m^3/min	acfm x 1000	
500	C,E	Fabric filter, 6/1 A/C	541	19.1	150
	A,B,F	Fabric filter, 6/1 A/C	266	9.4	66[d]
	G	Mist eliminator	348	12.3	44
	D[b]				0
					260
2000	C,E	Fabric filter, 6/1 A/C	825	29.1	225
	A,B,F	Fabric filter, 6/1 A/C	311	11.0	77[d]
	G	Mist eliminator	1367	48.3	145
	D	Fabric filter, 2/1 A/C	88	3.1	4[c]
					451
6500	C,E	Fabric filter, 6/1 A/C	1670	59.0	440
	A,B,F	Fabric filter, 6/1 A/C	453	16.0	105[d]
	G	Mist eliminator	4020	142.0	370
	D	Fabric filter, 2/1 A/C	215	7.6	13[c]
					928

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd plant does not manufacture PbO.

[c] Incremental cost between 2/1 A/C and 3/1 A/C baghouse.

[d] Includes additional 10 percent for modification of basic system of prevention of spark carryover.

Table 8-16. COST OF EMISSION CONTROL SYSTEMS

FCR CONTROL ALTERNATIVE II FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost, $1000
			m^3/min	acfm x 1000	
500	B,C,E	Fabric filter, 6/1 A/C	575	20.3	160
	F	Impingement and entrainment scrubber	198	.7	55
	A	Impingement and entrainment scrubber	34	1.2	27
	G	Mist eliminator	348	12.3	44
	D[b]				0
					286
2000	B,C,E	Fabric filter, 6/1 A/C	880	31.1	230
	F	Impingement and entrainment scrubber	198	7.0	55
	A	Impingement and entrainment scrubber	57	2.0	34
	G	Mist eliminator	1367	48.3	145
	D	Fabric filter, 2/1 A/C	88	3.1	4[c]
					468
6500	B,C,E	Fabric filter, 6/1 A/C	1798	63.5	465
	F	Impingement and entrainment scrubber	198	7.0	55
	A	Impingement and entrainment scrubber	127	4.5	46
	G	Mist eliminator	4020	142	370
	D	Fabric filter, 2/1 A/C	215	7.6	13[c]
					949

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-Process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd plant does not manufacture PbO.

[c] Incremental cost between 2/1 A/C and 3/1 A/C baghouse.

Table 8-17. COST OF EMISSION CONTROL SYSTEMS

FOR CONTROL ALTERNATIVE III FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost, $1000
			m^3/min	acfm x 1000	
500	C,E	Fabric filter, 6/1 A/C	541	19.1	150
	A,B,F	Impingement and entrainment scrubber	266	9.4	61
	G	Mist eliminator	348	12.3	44
	D[b]				0
					255
2000	C,E	Fabric filter, 6/1 A/C	825	29.1	225
	A,B,F	Impingement and entrainment scrubber	311	11.0	66
	G	Mist eliminator	1367	48.3	145
	D	Fabric filter, 2/1 A/C	88	3.1	4[c]
					440
6500	C,E	Fabric filter, 6/1 A/C	1670	59	440
	A,B,F	Impingement and entrainment scrubber	453	16	75
	G	Mist eliminator	4020	142	370
	D	Fabric filter, 2/1 A/C	215	7.6	13[c]
					898

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-Process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd plant does not manufacture PbO.

[c] Incremental cost between 2/1 A/C and 3/1 A/C baghouse.

Table 8-18. COST OF EMISSION CONTROL SYSTEMS FOR CONTROL ALTERNATIVE IV FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost, $1000
			m^3/min	acfm x 1000	
500	A,B,C	Impingement and entrainment scrubber	136	4.8	48
	E	Fabric filter, 6/1 A/C	472	16.7	98
	F	Impingement and entrainment scrubber	198	7.0	55
	G	Mist eliminator	349	12.3	44
	D[b]				0
					245
2000	A,B,C	Impingement and entrainment scrubber	204	7.2	50
	E	Fabric filter, 6/1 A/C	733	25.9	140
	F	Impingement and entrainment scrubber	198	7.0	55
	G	Mist eliminator	1367	48.3	145
	D	Fabric filter, 2/1 A/C	88	3.1	4[c]
					394
6500	A,B,C	Impingement and entrainment scrubber	408	14.4	72
	E	Fabric filter, 6/1 A/C	1517	53.6	260
	F	Impingement and entrainment scrubber	198	7.0	55
	G	Mist eliminator	4020	142	370
	D	Fabric filter, 2/1 A/C	215	7.6	13[c]
					770

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-Process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd plant does not manufacture PbO.

[c] Incremental cost between 2/1 A/C and 3/1 A/C baghouse.

Table 8-19. COST OF EMISSION CONTROL SYSTEMS FOR CONTROL ALTERNATIVE V FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost, $1000
			m^3/min	acfm × 1000	
500	A,B,C,F	Impingement and entrainment scrubber	334	11.8	67
	E	Fabric filter, 6/1 A/C	472	16.7	98
	G	Mist eliminator	349	12.3	44
	D[b]				0
					204
2000	A,B,C,F	Impingement and entrainment scrubber	402	14.2	70
	E	Fabric filter, 6/1 A/C	733	25.9	140
	G	Mist eliminator	1367	48.3	145
	D	Fabric filter, 2/1 A/C	88	3.1	4[c]
					359
6500	A,B,C,F	Impingement and entrainment scrubber	606	21.4	84
	E	Fabric filter, 6/1 A/C	1517	53.6	260
	G	Mist eliminator	4020	142	370
	D	Fabric filter, 2/1 A/C	215	7.6	13[c]
					727

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-Process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd plant does not manufacture PbO.

[c] Incremental cost between 2/1 A/C and 3/1 A/C baghouse.

Table 8-20. COST OF EMISSION CONTROL SYSTEMS FOR CONTROL ALTERNATIVE VI FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost
			m³/min	acfm	
100	A,B,C	Fabric filter, 6/1 A/C	117	4130	$ 39,100[c]
	E	Fabric filter, 6/1 A/C	402	14,200	85,000
	G	Mist eliminator	75	2660	11,500
	D[b]				0
	F[d]				0
					$ 135,000
250	A,B,C	Fabric filter, 6/1 A/C	124	4370	$ 40,700[c]
	E	Fabric filter, 6/1 A/C	428	15,100	90,000
	G	Mist eliminator	177	6260	24,500
	D[b]				0
	F[d]				0
					$ 155,000

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd or less plant does not manufacture PbO.

[c] Includes additional 10 percent for modification of basic system of prevention of spark carryover.

[d] For the purposes of this study, it is assumed that a plant making less than 500 bpd does not have a lead reclaim furnace.

Table 8-21. COST OF EMISSION CONTROL SYSTEMS
FOR CONTROL ALTERNATIVE VII FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost
			m^3/min	acfm	
100	A,B,C,E	Fabric filter, 6/1 A/C	518	18,300	$ 159,000[c]
	G	Mist eliminator	75	2,660	11,500
	D[b]				0
	F[d]				0
					$ 171,000
250	A,B,C,E	Fabric filter, 6/1 A/C	552	19,500	$ 171,000[c]
	G	Mist eliminator	177	6,260	24,500
	D[b]				0
	F[d]				0
					$ 196,000

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd or less plant does not manufacture PbO.

[c] Includes additional 10 percent for modification of basic system of prevention of spark carryover.

[d] For the purposes of this study, it is assumed that a plant making less than 500 bpd does not have a lead reclaim furnace.

Table 8-22. COST OF EMISSION CONTROL SYSTEMS FOR CONTROL ALTERNATIVE VIII FOR NEW PLANTS

Plant size, bpd	Affected facilities[a]	Control device to which facilities are vented	Exhaust rate		Installed cost
			m^3/min	acfm	
100	A,B,C	Impingement and entrainment scrubber	117	4130	$ 44,500
	E	Fabric filter, 6/1 A/C	402	14,200	85,000
	G	Mist eliminator	75	2660	11,500
	D[b]				
	F[c]				0
					$ 141,000
250	A,B,C	Impingement and entrainment scrubber	124	4370	$ 45,500
	E	Fabric filter, 6/1 A/C	428	15,100	90,000
	G	Mist eliminator	177	6260	24,500
	D[b]				0
	F[c]				
					$ 160,000

[a] Facility codes are as follows: A, grid casting furnace; B, grid casting machine; C, paste mixing; D, PbO manufacturing; E, Three-process operation; F, lead reclaim furnace; G, formation.

[b] For purposes of this study it is assumed that a 500-bpd or less plant does not manufacture PbO.

[c] For the purposes of this study, it is assumed that a plant making less than 500 bpd does not have a lead reclaim furnace.

Table 8-23. COSTS OF CONTROL SYSTEMS REQUIRED TO MEET TYPICAL SIP REGULATIONS[a]

Plant size, bpd	Facility	Exhaust rate		Installed cost, \$1000[b]	Direct operating cost, \$1000[b]	Annualized capital, \$1000[b]	Total Annualized cost, \$1000[b]
		m^3/min	acfm x 1000				
100	Paste mixing	51	2.2	35	3.8	6.7	10.5
250	Paste mixing	51	2.3	35	3.9	6.8	10.7
500	Paste mixing	67	2.4	36	3.9	6.9	10.8
	Lead reclamation	198	7.0	55	5.6	10.0	15.6
				91	9.5	16.9	26.4
2000	Paste mixing	91	3.2	40	5.7	8.6	14.3
	Lead reclamation	198	7.0	55	5.6	10.0	15.6
				95	11.3	18.6	29.9
6500	Paste mixing	156	5.5	50	8.9	11.3	20.2
	Lead reclamation	198	7.0	55	5.6	10.0	15.6
				105	14.5	21.3	35.8

[a] The control device consists of an impingement and entrainment scrubber.

[b] 4th-quarter 1977 dollars.

Table 8-24 . CAPITAL COSTS OF LEAD EMISSIONS CONTROL FROM NEW LEAD-ACID BATTERY MANUFACTURING FACILITIES - 100 BPD PLANT

Control alternative	Lead emissions,				Effectiveness of lead control, percent		Installed cost, 4th-qtr. 1977 dollars x 1000		Installed cost of control allocable to NSPS, 4th-qtr. 1977 dollars x 1000
	kg/day		lb/day						
	SIP	NSPS	SIP	NSPS	SIP	NSPS	SIP	NSPS	
VI	0.759	0.0122	1.67	0.0268	38	99.0	35	124	89
VII	0.759	0.0127	1.67	0.0268	38	99.0	35	159	124
VIII	0.759	0.0615	1.67	0.136	38	94.9	35	129	94

Table 8-25. CAPITAL COSTS OF LEAD EMISSIONS CONTROL FROM NEW LEAD-ACID BATTERY MANUFACTURING FACILITIES - 250 BPD PLANT

Control alternative	Lead emissions,				Effectiveness of lead control, percent		Installed cost, 4th-qtr. 1977 dollars x 1000		Installed cost of control allocable to NSPS, 4th-qtr. 1977 dollars x 1000
	kg/day		lb/day						
	SIP	NSPS	SIP	NSPS	SIP	NSPS	SIP	NSPS	
VI	1.90	0.0304	4.18	0.067	38	99.0	35	130	95
VII	1.90	0.0304	4.18	0.067	38	99.0	35	171	136
VIII	1.90	0.154	4.18	0.339	38	94.9	35	135	100

Table 8-26. . CAPITAL COSTS OF LEAD EMISSIONS CONTROL FROM NEW LEAD-ACID BATTERY MANUFACTURING FACILITIES, 500-BPD PLANT

Control alternative	Lead emissions, kg/day		Lead emissions, lb/day		Effectiveness of lead control, percent		Installed cost, 4th-qtr. 1977 dollars x 1000		Installed cost of control allocable to NSPS, 4th-qtr. 1977 dollars x 1000
	SIP	NSPS	SIP	NSPS	SIP	NSPS	SIP	NSPS	
I	3.82	0.063	8.42	0.138	39	99.0	91	216	125
II	3.82	0.086	8.42	0.193	39	98.6	91	242	151
III	3.82	0.097	8.42	0.214	39	98.4	91	211	120
IV	3.82	0.326	8.42	0.718	39	94.8	91	201	110
V	3.82	0.326	8.42	0.718	39	94.8	91	160	69

Table 8-27. CAPITAL COSTS OF LEAD EMISSIONS CONTROL FROM NEW LEAD-ACID BATTERY MANUFACTURING FACILITIES 2000-BPD PLANT

Control alternative	Lead emissions, kg/day		Lead emissions, lb/day		Effectiveness of lead control, percent		Installed cost, 4th-qtr. 1977 dollars x 1000		Installed cost of control allocable to NSPS, 4th-qtr. 1977 dollars x 1000
	SIP	NSPS	SIP	NSPS	SIP	NSPS	SIP	NSPS	
I	16.2	0.030	33.7	0.665	38	98.8	95	306	211
II	16.2	0.400	33.7	0.885	38	98.4	95	323	228
III	16.2	0.439	33.7	0.940	38	98.3	95	295	200
IV	16.2	1.350	33.7	2.880	38	94.8	95	249	154
V	16.2	1.360	33.7	2.880	38	94.8	95	214	119

Table 3-28.. CAPITAL COSTS OF LEAD EMISSIONS CONTROL FROM NEW LEAD-ACID BATTERY MANUFACTURING FACILITIES, 6500-BPD PLANT

Control alternative	Lead emissions, kg/day		Lead emissions, lb/day		Effectiveness of lead control, percent		Installed cost, 4th-qtr. 1977 dollars x 1000		Installed cost of control allocable to NSPS, 4th-qtr. 1977 dollars x 1000
	SIP	NSPS	SIP	NSPS	SIP	NSPS	SIP	NSPS	
I	50.1	0.988	110.5	2.18	39	98.8	105	558	453
II	50.1	1.310	110.5	2.89	39	98.4	105	579	474
III	50.1	1.430	110.5	3.15	39	98.3	105	528	423
IV	50.1	4.390	110.5	9.67	39	94.6	105	400	295
V	50.1	4.410	110.5	9.73	39	94.6	105	357	252

Table 8-29. NET CAPITAL COSTS OF CONTROL ALTERNATIVES FOR LEAD-ACID BATTERY MANUFACTURING PLANTS[a,b]

Control alternative	Installed cost of control systems allocable to NSPS, 4th-qtr. 1977 dollars x 1000				
	100 bpd plant	250 bpd plant	500 bpd plant[c]	2000 bpd plant[d]	6500 bpd plant[e]
I			170	366	838
II			196	383	859
III			165	355	808
IV			155	309	680
V			114	274	637
VI	101	120			
VII	136	161			
VIII	106	125			

[a] Includes controls for both lead emissions and sulfuric acid mist emissions and includes additional wastewater treatment capacity for the acid mist control system.

[b] Cost of controls necessary to meet SIP requirements are not included; these costs are estimated to be $91,000, $95,000, and $105,000 for 500-bpd, 2000-bpd, and 6500-bpd plants, respectively; and $35,000 for the 100 and 250 bpd plants.

[c] $1000 added for additional wastewater treatment capacity.

[d] $10,000 added for additional wastewater treatment capacity.

[e] $15,000 added for additional wastewater treatment capacity.

cost of each control alternative for both lead and acid mist emissions. Annualized control costs for new plants are shown in Tables 8-30 through 8-34. These costs are exclusive of those costs incurred to meet SIP regulations. The annualized costs of sulfuric acid mist control are shown in Table 8-35.

8.2.2 Modified/Reconstructed Facilities

8.2.2.1 Capital Cost of Control Systems - The cost for installing a control system in an existing plant that has been modified, reconstructed, or expanded (given the same exhaust gas parameters) is greater as a result of special design considerations, more complex piping requirements, etc. Estimating this additional installation cost or retrofit penalty is difficult because of many factors peculiar to the individual plant. In preparation of this section, such factors as lack of space, additional ducting, and additional engineering were considered.

Configuration of equipment in the existing plant governs the location of the control system. Depending on process or stack location, long ducting runs from ground level to the control device and to the stack may be required. A sizable increase in costs may be incurred if the control equipment must be placed on the roof, which may require steel structural support. Other cost components that may be increased

Table 8-30. ANNUALIZED COSTS OF LEAD CONTROLS ALLOCABLE TO A NEW SOURCE PERFORMANCE STANDARD FOR A NEW 100 BPD PLANT

Control alternative	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[a]		Direct costs, $1000/yr[b]	Annualized capital, $1000/yr[b]	Total annualized costs, $1000/yr[b]	Dollars per unit of lead removed,	
	kg	lb				kg	lb
VI	186	410	12.5	16.1	28.6	154	70
VII	186	410	26.1	18.2	44.3	238	108
VIII	174	383	9.0	17.1	26.1	150	68

[a] (SIP emissions - NSPS emissions) x 250 days/yr.

[b] Excludes costs associated with mixer which is controlled under SIP regulations. Does not include formation control costs and water treatment costs.

Table 8-31. ANNUALIZED COSTS OF LEAD CONTROLS ALLOCABLE TO A NEW SOURCE PERFORMANCE STANDARD FOR A NEW 250 BPD PLANT

Control alternative	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[a]		Direct costs, $1000/yr[b]	Annualized capital, $1000/yr[b]	Total annualized costs, $1000/yr[b]	Dollars per unit of lead removed,	
	kg	lb				kg	lb
VI	467	1030	13.2	17.2	30.4	65	30
VII	467	1030	27.9	19.1	47.0	101	45
VIII	438	965	9.4	18.2	27.6	63	29

[a] (SIP emissions - NSPS emissions) x 250 days/yr.

[b] Excludes costs associated with mixer which is controlled under SIP regulations. Does not include formation control costs and water treatment costs.

Table 8-32. ANNUALIZED COSTS OF LEAD CONTROLS ALLOCABLE TO A NEW SOURCE PERFORMANCE STANDARD FOR A NEW 500 BPD PLANT

Control alternative	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[a]		Direct costs, $1000/yr[b]	Annualized capital, $1000/yr[b]	Total annualized costs, $1000/yr[b]	Dollars per unit of lead removed	
	kg	lb				kg	lb
I	936	2070	27.6	19.9	47.5	51	23
II	934	2060	32.2	24.7	56.9	61	28
III	930	2050	27.7	19.9	47.6	51	23
IV	875	1930	10.5	19.7	30.2	35	16
V	875	1930	6.5	12.9	19.4	22	10

[a] (SIP emissions - NSPS emissions) x 250 days/yr.

[b] Excludes costs associated with mixer and reclamation facilities, both of which are controlled under SIP regulations. Does not include formation control costs and water treatment costs.

Table 8-33. ANNUALIZED COSTS OF LEAD CONTROLS ALLOCABLE TO A NEW SOURCE PERFORMANCE STANDARD FOR A NEW 2000-BPD PLANT

Control alternative	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[a]		Direct costs, $1000/yr[b]	Annualized capital, $1000/yr[b]	Total annualized costs, $1000/yr[b]	Dollars per unit of lead removed	
	kg	lb				kg	lb
I	3740	8240	71.7	36.2	108	29	13
II	3720	8190	71.7	42.2	122	33	15
III	3710	8180	71.7	35.2	107	29	13
IV	3490	7690	17.5	30.6	48.1	14	6.3
V	3490	7690	13.5	23.4	36.9	11	4.8

[a] (SIP emissions - NSPS emissions) x 250 days/yr.

[b] Excludes costs associated with mixer and reclamation facilities, both of which are controlled under SIP regulations. Does not include formation control costs and water treatment costs.

Table 8-34. ANNUALIZED COSTS OF LEAD CONTROLS ALLOCABLE TO A NEW SOURCE PERFORMANCE STANDARD FOR A NEW 6500-BPD PLANT

Control alternative	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[a]		Direct costs, $1000/yr[b]	Annualized capital $1000/yr[b]	Total annualized costs, $1000/yr[b]	Dollars per unit of lead removed	
	kg	lb				kg	lb
I	12,292	27100	200	83.5	284	23	11
II	12,202	26900	217	86.0	303	25	11
III	12,156	26800	198	78.5	277	23	10
IV	11,430	25200	33.5	57.5	91	8.0	3.6
V	11,430	25200	28.5	49.5	78	6.8	3.1

[a] (SIP emissions - NSPS emissions) x 250 days/yr.

[b] Excludes costs associated with mixer and reclamation facilities, both of which are controlled under SIP regulations. Does not include formation control costs and water treatment costs.

Table 8-35. ANNUALIZED COSTS OF SULFURIC ACID MIST CONTROLS FOR NEW FACILITIES[a,b]

Plant size, bpd	Direct operating costs of control system, $1000/yr	Annualized capital charges of control system, $1000/yr	Annualized cost of additional wastewater treatment, $1000/yr	Total annualized costs, $1000/yr
100	3.8	4.0	0.2	8.0
250	6.1	6.9	0.3	13.3
500	8.5	10.5	1.0	20.0
2000	17	27	6.0	50.0
6500	30	55	10.0	95.0

[a] Based on installation of a mist eliminator.

[b] No SIP regulations are applicable; 100 percent of costs allocable to NSPS regulations.

because of space restrictions and plant configuration are contractor's fees and engineering fees. These fees, estimated at 15 percent and 10 percent respectively under normal conditions, can be expected to increase to 20 percent and 15 percent respectively for a retrofit. These fees vary from place to place and job to job depending on the difficulty of the job, the risks involved, and current economic conditions. The fees cited are PEDCo's estimates.

The requirement for additional ducting can vary considerably, depending on plant configuration. For purposes of this study, it is estimated that approximately 50 percent more ducting may be required to install a control system in an existing plant.

If the space is tight within the plant, it may be necessary to install the control equipment on the roof. It is estimated that a roof-top installation could double the structural costs. The additional labor costs were determined by assuming that 10 percent of the labor will be required to tie the system into the process. This work would most likely have to be done at premium-time wage rates in accordance with governmental regulations and/or union agreements. These rates are assumed to be double the straight-time pay.

Applying these additional cost factors to those in Tables 8-10 and 8-11 shows that the cost of retrofit installations runs approximately 20 percent higher than the cost of new installations. Breakdowns of retrofit cost factors are shown in Tables 8-36 and 8-37 for fabric filters and wet collectors.

8.2.2.2 Annualized Cost of Control Systems - The annualized costs of control systems for modified/reconstructed facilities are calculated similarly to those for new facilities. The cost components that are proportional to capital costs, (see Table 8-12) are approximately 20 percent higher than those for new facilities.

8.2.2.3 Cost of Alternative Control Measures - The costs of the eight control alternatives listed in Table 8-6 were calculated on the same basis as those costs applicable to new facilities, (see Section 8.2.1.3). Tables 8-38 through 8-42 show the net capital and annualized costs for the eight control alternatives applicable to existing facilities that have been reconstructed or modified; Table 8-43 shows the costs of sulfuric acid mist control. The additional wastewater costs resulting from use of a fan separator have been added. For estimating purposes, it was assumed that these costs are double those incurred for a new plant. It is important to note that these costs are estimates. Retrofit situations vary over a broad range, since, for example, some

Table 8-36. COMPONENT CAPITAL COST FACTORS FOR A RETROFIT INSTALLATION OF A FABRIC FILTER AS A FUNCTION OF EQUIPMENT COST, Q

Component	Direct costs	
	Material	Labor
Equipment	1.00Q	0.25Q
Ductwork	0.06Q	0.30Q
Instrumentation	0.04Q	0.006Q
Electrical	0.11Q	0.16Q
Foundations	0.03Q	0.05Q
Structural	0.04Q	0.08Q
Sitework	0.02Q	0.02Q
Painting	0.004Q	0.02Q
Premium time labor		0.09Q
Total direct costs	1.30Q	0.98Q

Component	Indirect costs	
	Measure of costs	Factor
Engineering	15% material and labor	0.342Q
Contractor's fee	20% material and labor	0.456Q
Shakedown	5% material and labor	0.114Q
Spares	1% material	0.013Q
Freight	3% material	0.039Q
Taxes	3% material	0.039Q
Total indirect costs		1.003Q
Contingencies - 20% of direct and indirect costs		0.656Q
Total capital costs		3.94Q

Table 8-37. COMPONENT CAPITAL COST FACTORS FOR A RETROFIT INSTALLATION OF A WET COLLECTOR (SCRUBBER OR MIST ELIMINATOR) AS A FUNCTION OF EQUIPMENT COST, Q

Component	Direct costs	
	Material	Labor
Equipment	1.00Q	0.25Q
Ductwork	0.04Q	0.20Q
Instrumentation	0.04Q	0.006Q
Electrical	0.11Q	0.16Q
Foundations	0.03Q	0.05Q
Structural	0.04Q	0.08Q
Sitework	0.02Q	0.02Q
Painting	0.004Q	0.02Q
Piping	0.15Q	0.16Q
Premium Time Labor	-	0.09Q
Total direct costs	1.43Q	1.03Q

Component	Indirect costs	
	Measure of costs	Factor
Engineering	15% material and labor	0.369Q
Contractor's fee	20% material and labor	0.492Q
Shakedown	5% material and labor	0.123Q
Spares	1% material	0.014Q
Freight	3% material	0.042Q
Taxes	3% material	0.042Q
Total indirect costs		1.082Q
Contingencies - 20% of direct and indirect cost		0.708Q
Total capital costs		4.25Q

Table 8-38.. COSTS OF LEAD EMISSIONS CONTROL ALTERNATIVES FOR AN EXISTING 100-BPD PLANT

Control alternative[a]	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[b]		Installed cost, $1000[c]	Direct operating cost, $1000/yr[c]	Annualized capital charges, $1000/yr[c]	Total annualized cost, $1000/yr[c]	Dollar per unit of lead removed	
	kg	lb					kg	lb
VI	186	410	107	13.7	19.1	32.8	176	80
VII	186	410	149	27.8	22.4	50.2	270	123
VIII	174	383	113	10.3	20.3	30.6	176	80

[a] See Table 8-5 for a description of each Control Alternative.

[b] (SIP emissions - NSPS emissions) x 250 days/yr.

[c] Does not include costs associated with mixing and reclaim facilities, both of which are controlled under SIP regulations.

Table 8-39. COSTS OF LEAD EMISSIONS CONTROL ALTERNATIVES FOR AN EXISTING 250-BPD PLANT

Control alternative[a]	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[b]		Installed cost, \$1000[c]	Direct operating cost, \$1000/yr[c]	Annualized capital charges, \$1000/yr[c]	Total annualized cost, \$1000/yr[c]	Dollar per unit of lead removed	
	kg	lb					kg	lb
VI	467	1030	114	14.5	20.4	34.9	74	34
VII	467	1030	163	29.8	23.7	53.5	115	52
VIII	438	965	120	10.8	21.6	32.4	74	34

[a] See Table 8-5 for a description of each Control Alternative.

[b] (SIP emissions - NSPS emissions) x 250 days/yr.

[c] Does not include costs associated with mixing and reclaim facilities, both of which are controlled under SIP regulations.

Table 8-40. COSTS OF LEAD EMISSIONS CONTROL ALTERNATIVES FOR AN EXISTING 500-BPD PLANT

Control alternative[a]	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[b]		Installed cost $1000[c]	Direct operating cost, $1000/yr[c]	Annualized capital charges, $1000/yr[c]	Total annualized cost $1000/yr[c]	Dollar per unit of lead removed	
	kg	lb					kg	lb
I	936	2070	150	29.4	24.2	53.6	57	26
II	934	2060	181	34.3	29.8	64.1	69	31
III	930	2050	144	29.4	24.0	53.4	57	26
IV	875	1930	132	12.0	23.4	35.4	40	18
V	875	1930	83	7.5	15.2	22.7	26	12

[a] See Table 8-5 for a description or each Control Alternative.

[b] (SIP emissions - NSPS emissions) x 250 days/yr.

[c] Does not include costs associated with mixing and reclaim facilities, both of which are controlled under SIP regulations.

Table 8-41. COSTS OF LEAD EMISSIONS CONTROL ALTERNATIVES FOR AN EXISTING 2000-BPD PLANT

Control alternative[a]	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[b]		Installed cost $1000[c]	Direct operating cost, $1000/yr[c]	Annualized capital charges, $1000/yr[c]	Total annualized cost $1000/yr[c]	Dollar per unit of lead removed	
	kg	lb					kg	lb
I	3740	8240	253	74.7	43.4	118	32	14
II	3710	8190	274	82.9	50.0	133	36	16
III	3710	8180	240	74.5	42.0	117	32	14
IV	3490	7690	185	19.7	36.1	55.8	16	7.3
V	3490	7690	143	15.2	27.4	42.6	12	5.5

[a] See Table 8-5 for a description of each Control Alternative.

[b] (SIP emissions - NSPS emissions) x 250 days/yr.

[c] Does not include costs associated with mixing and reclaim facilities, both of which are controlled under SIP regulations.

Table 8-42. COSTS OF LEAD EMISSIONS CONTROL ALTERNATIVES FOR AN EXISTING 6500-BPD PLANT

Control alternative[a]	Effectiveness of lead removal compared with SIP regulations, units Pb removed/yr[b]		Installed cost $1000[c]	Direct operating cost, $1000/yr[c]	Annualized capital charges, $1000/yr[c]	Total annualized cost $1000/yr[c]	Dollar per unit of lead removed	
	kg	lb					kg	lb
I	12,292	27100	544	206	98.9	305	25	11
II	12,202	26900	569	224	102	326	27	12
III	12,156	26800	508	204	92.9	297	24	11
IV	11,430	25200	354	37.6	67.5	105	9.1	4.2
V	11,430	25200	302	42.0	58.1	100	8.7	4.0

[a] See Table 8-5 for a description of each Control Alternative.

[b] (SIP emissions - NSPS emissions) x 250 days/yr.

[c] Does not include costs associated with mixing and reclaim facilities, both of which are controlled under SIP regulations.

Table 8-43. SULFURIC ACID MIST CONTROL COSTS FOR EXISTING RECONSTRUCTED/ MODIFIED BATTERY FORMATION FACILITIES[a]

Plant size, BPD	Installed costs, $1000		Direct operating costs of mist eliminator $1000/yr	Annualized capital charges of mist eliminator $1000	Annualized costs of additional water treatment $1000	Total annualized costs, $1000
	Mist eliminator	additional wastewater treatment capacity				
100	13.8	0.6	4.0	4.4	0.6	9.0
250	29.4	0.6	6.4	7.7	0.6	14.7
500	52.8	2.0	9.1	12.0	2.0	23.1
2000	174	20.0	19.0	43.9	12.0	74.9
6500	444	30.0	35.2	67.6	20.0	123

[a] 4th-quarter 1977 dollars

are reconstructions and others are expansions. Thus it is unlikely that the new plant exhaust parameters would fit all the retrofit applications. For estimating purposes, it must be assumed that exhaust parameters remain constant. Additionally, plants that reconstruct or modify their facilities are not likely to undertake changing all their facilities at the same time. Consequently, the overall capital and annualized costs shown in Tables 8-38 through 8-43 are not likely to be incurred at the same time. All the costs must be incurred at some point in time, as each of the facilities becomes an affected facility.

8.2.3 Cost-effectiveness of Alternative Control Measures

It is informative to compare the annualized costs of the various alternative lead control measures to the quantities of lead removed by them. This comparison, or cost-effectiveness analysis, is done in this section for the five sizes of the new model battery plants. (Since an NSPS impacts most heavily on new, rather than existing plants, the cost-effectiveness analysis will be limited to them.)

There are several ways this comparison can be made. First, the various incremental annualized costs (that is, those costs solely due to NSPS control) may be divided by the incremental quantities of lead removed. Tables 8-30 through 8-34 list these cost-effectiveness quotients. It is clear from the tables that the quotients vary both with the plant capacity and the control alternative. The quotients vary from nearly $7.00 to $25.00 per Kg in the 6500 battery per day (bpd) plant, but are much higher in the smallest plant (100 bpd) where they range from $150.00 to $238.00 per Kg. This clearly indicates that control costs benefit from a positive economy of scale.

The quotients for control alternatives I through VIII are plotted in Figure 8-4 against the model batter plant capacity. Note, first of all, that the cost-effectiveness quotients decrease significantly as the plant size increases. This demonstrates the economy of scale characteristic mentioned above. Moreover, as the size increases to the largest capacity, 6500 bpd, the quotients continue to decrease, although more gradually. If extrapolated beyond 6500 bpd, the curves would tend to approach certain limiting values. Beyond these values, cost-effectiveness would be effectively independent of plant size.

Also notice that the cost-effectiveness curves are not ordered according to their respective control efficiencies. For instance, the curve for Alternative I, the most stringent with 99 percent lead emissions control, lies below the curve for Alternative II, which represents a lower control efficiency (98 percent) for the larger plants. Likewise the curve for Alternative VI lies below an equally efficient

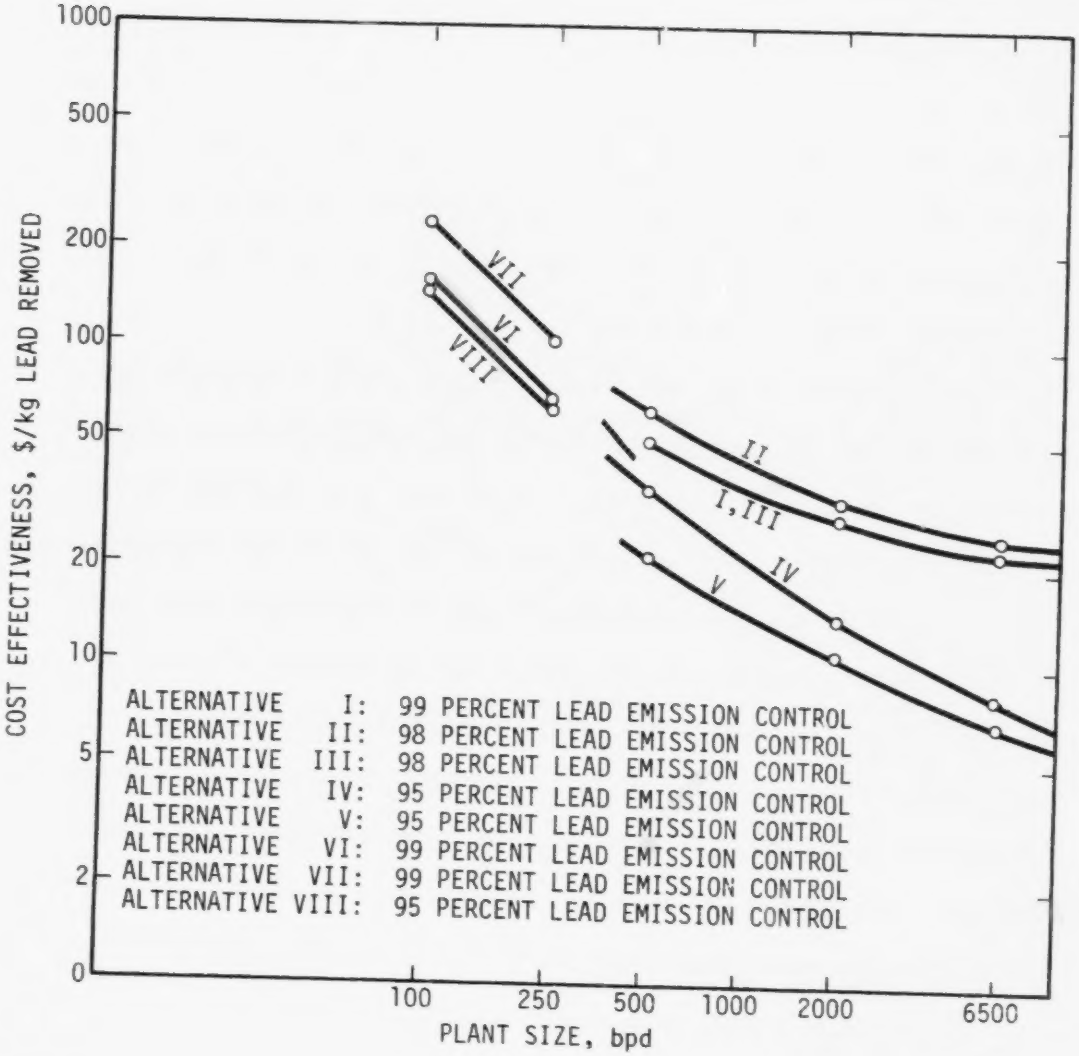

Figure 8-4 Cost-effectiveness of Model Plant Control Alternatives.

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Alternative VII and barely above Alternative VIII which represents a much lower efficiency (95 percent). In other words, one would expect Alternatives I, VI, and VII to be less cost-effective (i.e., more costly) than all the others, simply because they require the greatest degree of control. This, however, is not the case in Alternatives I and VI. This situation can be understood if it is remembered that each alternative represents a different group of control systems and for each of these systems there is a different relationship between cost and gas flowrate. For example, the Alternative I costs for the 2000 and 6500 bpd plants include three fabric filters, while the corresponding Alternative II costs include two fabric filters and two impingement and entrainment scrubbers---a total of four lead control systems. Alternative VI is less costly than Alternative VII because the moist mixer gases and the three-process operation exhausts are vented to separate fabric filters. Thus Alternative VI does not require heating as large a fabric filter as does Alternative VII.

Finally, as Figure 8-4 shows, Alternative VIII (at 95 percent) is the most cost-effective for the smallest plants, while Alternative V (95 percent) is the most cost-effective for the 2000 and 6500 bpd plant sizes.

8.3 OTHER COST CONSIDERATIONS

8.3.1 Costs Imposed by Water Pollution Regulations

Effluent limitations, new source standards, and pretreatment standards regulating water emissions from lead-acid battery plants are expected to be proposed in 1980. Upon promulgation of these regulations, existing plants discharging to surface waters will be subject to effluent limitations which will reflect best practicable technology (BPT) currently available. After 1983, these effluent limitations will reflect best available technology (BAT) economically achievable. New battery plants discharging to surface waters will be subject to new source standards which will reflect BAT.

Existing plants discharging to municipal treatment systems will be subject to Federal pretreatment standards which will reflect BPT. New plants discharging to municipal treatment systems will be required to meet Federal pretreatment standards which will be more stringent than those for existing plants.

One study reports that of the 200 lead-acid battery plants in the United States in 1972, approximately 150 were neutralizing their wastewater effluents. Of these 150 plants, about 46 use lime treatment and 14 use caustic treatment.[23] The number of plants applying such treatments will increase rapidly as Federal effluent limitations become effective. The costs associated with water pollution control are presented in Table 8-44. Wastewater generated by impingement and entrainment scrubbers used to control atmospheric lead emissions would make up only a small percentage of the wastewater generated at a lead-acid battery plant. The additional wastewater would not significantly affect the costs of water treatment. Use of a mist eliminator to control acid mist requires increased water treatment capacity. This extra cost is included with the mist eliminator control costs in Table 8-43.

8.3.2 Costs Imposed by Solid Waste Disposal Regulations

As mentioned earlier, 60 plants were producing wastewater treatment sludges in 1972. These sludges require some type of landfill disposal. Estimated annualized costs for providing solid waste disposal for lime and caustic treatment facilities are presented in Table 8-45 and Table 8-46, respectively. These costs are based on costs applicable to an 1800-BPD plant[24] and scaled to 100, 250, 500, 2000, and 6500 bpd plants by use of the $t^{0.6}$ law.

8.3.3 Costs Associated with OSHA Compliance

The costs of compliance with regulations of the Occupational Safety and Health Administration have been estimated for five factors, as shown in Table 8-47, which also lists the assumptions upon which the compliance cost estimate is based. The 25 batteries/man-day figure is an average based on information obtained from several plant representatives.

Table 8-44. ANNUALIZED COSTS ASSOCIATED WITH WATER POLLUTION CONTROL

(4th-Quarter 1977 Dollars)[a]

Degree of control	Annualized costs by plant size, $1000				
	100 bpd[b]	250 bpd[b]	500 bpd[c]	2000 bpd[c]	6500 bpd[c]
Pre-NPDES[d]	2.2	4.5	19.9	60.5	162
Best Practicable Technology, (BPT)[e,f]	18.6	30.6	81.5	169	314
Best Available Technology, (BAT)[e,f]	24.0	40.5	116	262	510

[a] Costs obtained from references were updated per the Chemical Engineering (CE) Index for Plant Costs.

[b] Based on 0.075 m^3 (20.0 gal) water per battery. This represents the mix of wet and dry units typical for small (less than 500 BPD) plants reported to U.S. EPA.

[c] Based on 0.25 m^3 (66.5 gal) water per battery.[25]

[d] Reference 26.

[e] Reference 27.

[f] Since effluent limitations and new source standards for battery manufacturing. have not been proposed, the costs set forth for BPT and BAT are estimates, rather than firm costs.

Table 8-45. ANNUALIZED COSTS ASSOCIATED WITH SOLID WASTE DISPOSAL FOR PLANTS USING LIME NEUTRALIZATION

(4th Quarter-1977 Dollars)[a]

Type of disposal	Annualized costs by plant size, $1000				
	100 bpd	250 bpd	500 bpd	2000 bpd	6500 bpd
On-site land storage	4.4	8.7	14.7	41.2	106
On-site land storage with leachate collection and treatment system	6.5	13.6	23.5	67.6	176
Chemical fixation and landfill	15.0	30.5	51.4	150	382

[a] Costs for 1800 bpd were obtained from Reference 28 and scaled to various plant sizes using the $t^{0.6}$ law and updated to 4th quarter-1977 costs per the Chemical Engineering (CE) Index for Plant Costs.

Table 8-46. ANNUALIZED COSTS ASSOCIATED WITH SOLID WASTE DISPOSAL FOR PLANTS USING CAUSTIC SODA NEUTRALIZATION

(4th Quarter-1977 Dollars)[a]

Type of disposal	Annualized costs by plant size, $1000		
	100-500 bpd	2000 bpd	6500 bpd
On-site landfill	<0.5	2.2	5.3
Off-site landfill (contractor)	<0.5	0.9	2.0
Off-site landfill	<0.5	0.9	2.0
Secured landfill	<0.5	1.6	4.0

[a] Costs for 1800 bpd were obtained from Reference 29 and scaled to various plant sizes using the $t^{0.6}$ law and updated to 4th quarter-1977 costs per the Chemical Engineering (CE) Index for Plant Costs.

Table 8-47. COST FACTORS AND ASSUMPTIONS FOR OSHA COMPLIANCE (METRIC UNITS)

OSHA Factor	Assumptions upon which estimate is made
Employee care	° 25 batteries/man-day ° \$35/employee/mo.
Heat for makeup air	° 4600 degree-days/year ° \$3.00/GJ ° Air volumes as follows: 100-bpd plant 600 m^3/min, 8 hr/day 250-bpd plant 730 m^3/min, 8 hr/day 500-bpd plant 1160 m^3/min, 8 hr/day 2500-bpd plant 2580 m^3/min, 16 hr/day 6500-bpd plant 6360 m^3/min, 24 hr/day
Exhaust hoods and ducts	° 457 meters/min velocity ° 122 m ductwork/plant ° annualized costs = 20% of capital costs
Electricity	° \$0.03/kWh ° Pressure loss: 1.6 Pa/m duct ° Each plant has four separate systems with overall ΔP of 100 Pa. (including fittings & dampers, etc.)
Fans & motors	° Four equal sized units per plant ° Annualized costs = 30% of capital costs

Table 8-47A. COST FACTORS AND ASSUMPTIONS FOR OSHA COMPLIANCE (ENGLISH UNITS)

OSHA factor	Assumptions upon which estimate is made
Employee care	° 25 batteries/man-day ° $35/employee/mo.
Heat for makeup air	° 4600 degree-days/year ° $3.00/MM Btu ° Air volumes as follows: 100-bpd plant 21,000 cfm, 8 hr/day 250-bpd plant 25,600 cfm, 8 hr/day 500-bpd plant 40,800 cfm, 8 hr/day 2000-bpd plant 91,000 cfm, 16 hr/day 6500-bpd plant 224,000 cfm, 24 hr/day
Exhaust hoods and ducts	° 1500 fpm velocity ° 400 ft ductwork/plant ° annualized costs = 20% of capital costs
Electricity	° $0.03/kWh ° Pressure loss: 0.2 in. W.G./100 lf duct ° Each plant has four separate systems with overall ΔP of 0.4 in. W.G. (including fittings and dampers, etc.)
Fans and motors	° Four equal sized units per plant ° Annualized costs = 30% of capital costs

Simply put, it represents plant capacity divided by plant employees. It is estimated that $35 per employee per month is required for blood tests, laundry, and shower facilities.[30] All the plant air that is exhausted must be made up. In cold climates, this requires the addition of heat. The heating costs are based on 4600 degree days per year (average for St. Louis, Missouri), a fuel cost of $3.00 per MM Btu, and a heat exchange efficiency of 60 percent. If the plant uses propane, the costs will be somewhat higher. The volume of air to be heated corresponds to the exhaust rates shown in Table 8-15. The capital costs of ductwork, hoods, fans, and motors are based on engineering judgment and published data.[31] Likewise, the ventilation system pressure drop, velocity, and length and number of runs are based on engineering judgment. Calculated annualized costs for the control alternatives are approximately 30 percent of the capital costs, (See Tables 8-29 through 8-35) . That percentage value is used for the costs associated with the fans and motors. Since the ductwork and hoods require less maintenance and no operating labor, the associated annualized costs are estimated at 20 percent of the capital costs.

Overall OSHA compliance costs are shown in Table 8-48. These costs do not include the impact of any new regulations or amendments that OSHA may be considering. Should OSHA adopt more stringent standards, the compliance costs could easily double.

The battery industry has no operations that require the expenditure of funds for noise control.

Table 8-48. ESTIMATED OSHA COMPLIANCE COSTS FOR LEAD-ACID BATTERY MANUFACTURING PLANTS

	Annualized costs, $1000				
OSHA factor	100 bpd	250 bpd	500 bpd	2000 bpd	6500 bpd
Employee care	1.7	4.2	8.4	33.6	109.0
Heat for makeup air	4.1	5.2	8.2	39.4	132.0
Exhaust hoods and ducts	1.6	2.0	2.4	3.6	5.5
Electricity	0.1	0.1	0.2	1.1	4.1
Fans and motors	4.6	4.8	5.6	8.8	18.7
Totals	12.1	16.3	24.8	86.5	269.3

8.3.4 Costs Associated with Compliance Testing

Each source subject to a New Source Performance Standard must undergo a compliance testing program. In the case of lead-acid battery manufacturing plants, the following facilities and pollutants may be affected:

Facility	Pollutant
Grid Casting	Lead
Paste Mixer	Lead
Lead Oxide Manufacturing	Lead
Three-Process Operation	Lead
Lead Reclamation	Lead
Formation	Sulfuric Acid Mist

Concentrations of lead and sulfuric acid mist in well-controlled gas streams from these facilities are very small and extended sampling time is required to gather a measurable sample. For example, it was necessary to sample for 16 straight hours to gather a measurable sulfuric acid mist sample for a test performed under this study. It is estimated that a standard three-run compliance test program will cost approximately $6,000-$7,500 for lead and $10,000-$11,500 for sulfuric acid mist.* These costs include the expenses of a presurvey travel, lodging and report preparation for the test crews. The total impact of these costs are shown in Table 8-49. Except for the fact that smaller plants, for purposes of this study, have fewer Affected Facilities, the test costs are insensitive to plant size. As can be seen, the compliance test program is a large proportion of, and in addition to, the capital costs of the Control Alternatives.

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* The higher cost applied to a single stack test program. The smaller figure applies to any stacks sampled beyond the first stack in a multi-stack test program.

Table 8-49. COMPLIANCE TESTING COSTS APPLICABLE TO NEW SOURCE PERFORMANCE STANDARDS FOR LEAD-ACID BATTERY MANUFACTURING FACILITIES

Control Alternative	Plant Size Range, BPD	No. of Stacks		Total Cost, \$1,000
		Pb	H_2SO_4	
I	≧ 500	3	1	29.5
II	≧ 500	4	1	35.5
III	≧ 500	3	1	29.5
IV	≧ 500	4	1	35.5
V	≧ 500	3	1	29.5
VI	< 500	2	1	23.5
VII	< 500	1	1	17.5
VIII	< 500	2	1	23.5

8.3.5 Composite Costs of Environmental Regulatory Requirements

This subsection summarizes the cost impacts of the various environmental regulations discussed earlier and compares these costs with those related to air pollution control. These latter costs consist of costs for SIP compliance and costs related to compliance with an NSPS. Table 8-50 lists the various annualized costs of compliance with environmental regulatory requirements for typical new plants. The costs of compliance source tests, shown in Table 8-49, are not annualized.

Table 8-50. ANNUALIZED COSTS OF COMPLIANCE WITH ENVIRONMENTAL REGULATORY REQUIREMENTS FOR TYPICAL NEW LEAD-ACID BATTERY MANUFACTURING PLANTS

Environmental regulatory requirements	Annualized costs by plant size, \$1000 4th quarter-1977 dollars				
	100 bpd	250 bpd	500 bpd	2000 bpd	6500 bpd
Water pollution control[a]	24.0	40.5	116	262	510
Solid waste disposal[b]	6.5	13.6	23.5	67.6	176
OSHA	12.1	16.3	24.8	86.5	269
Air pollution control					
SIP[c]	12.9	12.9	36.0	41.0	47.5
NSPS[d]	36.6	43.7	67.5	158	379
Totals	92	127	268	615	1,380

[a] Based on BAT controls.

[b] Assumes lime neutralization of waste and on-site land storage with leachate collection and treatment system.

[c] [SIP-related capital costs ÷ NSPS-related capital costs] x [NSPS-related annualized costs].

[d] Control alternatives I and VI.

8.3.6 Regulatory Agency Manpower Requirements

States are required to adopt regulations for non-criteria pollutants addressed in the Federal standards and to obtain EPA approval of a plan to implement enforcement of these regulations. State and local agencies will be responsible for issuance of construction permits and for compliance verification of new sources. These agencies will be responsible for permits, compliance schedules, enforcement, and compliance verification on existing sources. In addition, agencies will provide periodically updated reports on compliance status and legal matters relative to new and existing sources.

In summary, regulation of sulfuric acid mist emissions under an NSPS adds another pollutant to the list of those to be regulated by state agencies. As a practical matter, it is estimated that particulate matter and sulfur oxides probably require 80 percent of an agency's resources currently. It is further estimated that the remaining 20 percent of their workload will be increased by less than 1/20, giving an estimated net increase of 1 percent in the cost of agency operations. Typical annual budgets for state air programs range from $250,000 to $2 million. Therefore a proposed NSPS for the formation facility in lead battery plants may require an additional cost of $2500 to $20,000 for local agencies.

8.4 ECONOMIC IMPACT OF CONTRCL ALTERNATIVES

This section presents an assessment of economic impacts of alternative NSPS lead control systems and sulfuric acid mist control. Integral to this assessment are the NSPS compliance cost data developed in the technical analysis (described in Section 8.2) and the industry economic conditions discussed in Section 8.1 and in this section. The assessment focuses only on incremental cost effects of the regulations which include both sulfuric acid mist control and NSPS lead particulate control. Th scope of the impact analysis if limited to establishments engaged in manufacturing lead-acid storage batteries.

The economic assessment includes an evaluation of the impact of the proposed regularoty alternatives on industry growth and prices. It considers potential impacts on the operations of existing plants, categorized by size, product mix, processes performed, age, and financial status.

As will be shown in the following pages, the incremental cost impact of NSPS regulations on the lead-acid battery industry as a whole will not cause significant economic disruption. The more significant impacts are summarized as follows:

- Increased long-run prices on the order of 1 to 1.5 percent of the average value of battery shipments are predicted.

- Industry volume is projected to grow throughout the period of NSPS introduction at an average annual growth rate of 3.5 percent or more per year. This growth rate will not be significantly affected by a pass-through of NSPS costs.

- Impacts on the lead-acid storage battery manufacturing industry are limited because of the general lack of economically feasible alternative sources (such as imports) or substitutes (alternative energy sources) for the major battery use applications.

- No significant regional, community, or balance of trade impacts are expected as a result of the NSPS regulation.

- The impact of NSPS lead and sulfuric acid mist control on small plants (producing in the range of 100 batteries per day) will be substantial. Return on investment will fall from 11 to 19 percentage points and obtaining financing of control equipment will be difficult. This impact is further aggravated when compliance testing costs are also considered.

Although it is believed that the NSPS regulation in itself will not have a significant effect on the projected baseline conditions of the industry, the complete "package" of governmental regulations, as discussed in Section 8.3, probably will have significant impact. The cumulative cost impact is estimated to be over 5 percent of the value of shipments. The total cost increase may be higher, since a number of these regulatory programs are not yet finalized.

8.4.1 Regulatory Alternatives

In response to the regulations analyzed here, the plant manager will generally have more than one control alternative available to meet them. Of these, some alternatives will involve higher capital expenditure costs and thus higher total unit costs than others.

Only impacts under Alternative I are reviewed in the analysis of large plants. This alternative was selected because control Alternative I has been determined in section 8.2 to be the best control technology for emission reduction.

For small plants control Alternatives VI and VII represent the best control technology for emission reduction. Alternative VI was selected for analysis because it has lower capital and annualized costs than alternative VII.

The basic economic analysis assumes that NSPS regulations will impact in the following manner:

1. New sources will be subject to the regulations on all facilities. Facilities will be considered reconstructed and will be covered if "(1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility and (2) it is technologically and economically feasible to meet the applicable standards set forth...". With certain exceptions, "any physical or operational change to an existing facility which results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification..." and the facility will come under NSPS.

2. Based on 1 above, it is assumed that expansion of

any facility at an existing source will be subject to the regulations, no matter how small the resulting increase in capacity. This will result from the reconstruction and modification provisions of the NSPS.

3. Technological improvements at existing sources, whether or not they involve expansion of output capacity, are subject to the NSPS reconstruction and/or modification provisions, under conditions similar to those stated in 2 above.

4. Because of the NSPS definition of "facilities", it is reasonable to assume that all replacement of major capital items at existing plants will fall under NSPS, including cases that involve neither expansion of capacity nor technical upgrading. This is true because replacement would generally be covered under reconstruction. Thus, all facilities at existing plants that continue operations on a long-term basis will eventually fall under NSPS, except insofar as some equipment might effectively be reconstructed through piecemeal expenditures on maintenance and repair.

These assumptions governing interpretation of the regulations have been formulated with the objective of portraying cases having the greatest potential impacts.

The analysis of modified/reconstructed plants assumes a "worst case" analysis, i.e., the replacement/reconstruction of all affected facilities immediately after the promulgation of the regulations. "Worst case" analysis is standard practice in NSPS economic impact assessments.

8.4.1.1 Limitations of the Analysis

The socio-economic impact analysis in Section 8.4 is subject to the following general limitations:

1. The analysis is based on publicly available information, interviews with selected industry representatives and information obtained in earlier EPA studies. No formal economic survey of lead-acid battery plants was possible, therefore many of the observations about industry conditions and trends are based on qualitative information.

2. Although the analysis is designed to measure incremental cost impacts, no attempt was made to survey existing plants concerning specific SIP, water pollution control or current OSHA requirements, or the current status of compliance with these requirements. All SIP and current OSHA required equipment is assumed to be in place.

8.4.2 Market Impact of NSPS

8.4.2.1 Baseline Industry Expansion

As described earlier, shipments of lead-acid storage battery units increased at an average annual rate of about 5 percent between 1968 and 1977. Although the industry should experience steady growth, the future rate of growth is subject to much speculation. Over-all growth estimates obtained from plants responding to EPA inquiry (Section 114 Letters) range from 40 to 120 percent through 1985. This is a projected average annual rate of 3.5 to 8.2 percent. BCI agrees with the lower estimate. Responses to EPA's Section 114 Letters indicate that nearly all growth would be realized through expansion of existing larger plants (more than 2000 BPD capacity).

The lead-acid battery industry is intimately tied to the automobile industry, through both the original equipment and replacement battery markets. As such, the industry is strongly dependent on auto production for its economic viability. Expanding auto sales not only stimulate current production of lead-acid batteries, but also production 3 to 4 years in the future when previously purchased automobiles are in need of a replacement battery. Current demand for batteries is dependent on current and previously purchased automobiles, i.e., current automobile sales, sales 3 to 4 years ago, and sales 6 to 8 years ago.

Most of the output expansion in the lead-acid storage battery industry occurs through modifications and additions to existing plants. The major mode of output expansion in the lead-acid storage battery industry since the mid-1950's has been expansion of existing plants in the 1200-4000 BPD range. In late 1974, plants less than 10 years of age comprised only 22 percent of all establishments and accounted for less than 20 percent of lead-acid battery capacity. Larger new plants (with capacities of 1600 BPD or higher) accounted for only 15 percent of estimated industry capacity. By contrast, plants between 10 and 24 years old producing 1200 to 4000 BPD accounted for about 37 percent of estimated capacity[32].

8.4.2.2 Control Costs

The regulatory alternatives under consideration for the lead-acid battery manufacturing industry include acid mist controls on the dry formation process. If a standard is promulgated for acid mist emissions under Section 111(b) of the Clean Air Act, States would be required to develop standards for acid mist emissions from existing formation processes. In addition, existing plants would be required to meet the NSPS for any facilities which are newly constructed, modified, or reconstructed.

Table 8.51 presents the annual sulfuric acid mist control cost for large existing plants and the cost per battery at capacity and at an 80% operating rate. Capacity is battery production per day multiplied by the number of annual working days (250 working days/year is used). The operating rate is defined as actual production divided by capacity production.

Table 8.51

SULFURIC ACID CONTROL COSTS - EXISTING PLANT

WET/DRY OR DRY FORMING

(In Thousand of Dollars)

	500 BPD	2000 BPD	6500 BPD
Annual Cost	$23.1	$74.9	$123.0
Cost Per Battery at Capacity	$.184	$ .15	$ .077
Cost Per Battery at 80% Capacity	$ .23	$.187	$ .096

Table 8.52 shows the annual sulfuric acid mist control and lead NSPS control costs for plants at capacity and at 80% of capacity, if all plants were to replace their affected facilities or to fall under the reconstructed/modified clause immediately after promulgation of the standard.

Table 8.52

INCREMENTAL ANNUAL SULFURIC ACID MIST AND LEAD NSPS CONTROL COSTS

RECONSTRUCTED/MODIFIED PLANT - CONTROL ALTERNATIVE I

(In Thousand of Dollars)

	500 BPD	2000 BPD	6500 BPD
Annual Cost	$76.7	$192.9	$428.0
Cost Per Battery at Capacity	$ .61	$ .385	$ .261
Cost Per Battery at 80% Capacity	$.767	$ .482	$ .329

Table 8.53 presents the annual control costs for new plants.

Table 8.53

INCREMENTAL ANNUAL SULFURIC ACID MIST AND LEAD NSPS CONTROL COSTS

NEW PLANT - CONTROL ALTERNATIVE I

(In Thousand of Dollars)

	500 BPD	2000 BPD	6500 BPD
Annual Cost	$70.6	$182.9	$407.0
Cost Per Battery at Capacity	$ .56	$ .365	$ .25
Cost Per Battery at 80% Capacity	$.706	$ .456	$ .31

8.4.2.3 Demand Conditions

No quantitative studies of the price elasticity of demand for batteries have been identified during this analysis. Price elasticity of demand is defined as the percent change in sales divided by the corresponding percent price change, and determines the quantitative effect on sales from a change in the price charged for a battery.

Batteries are purchased for replacement of existing batteries and for inclusion in original equipment. In the replacement market the price elasticity of demand for a commodity is determined by the availability of good substitutes for the product, the number of uses to which the product can be put, and the price of the commodity relative to consumer incomes. In the original equipment market, a battery is not purchased per se, but is purchased as part of a larger product (such as an automobile, golf cart or industrial equipment). The elasticity of price demand in this case is determined by the availability of good substitutes for the battery in its use in the final product, the price elasticity of demand for the final product and the ratio of the cost of the battery to the total cost of the product of which it is a part. The smaller the number of good substitutes, the smaller the number of uses to which the product can be put, and the smaller the price of the product relative to consumer's income, the lower is the elasticity of demand for the product.

By the same reasoning the smaller the ratio of the battery's cost to the total cost of the final product of which it is part and the lower the price elasticity of the final product, the more inelastic is the demand for the product. Of these factors the availability of adequate substitutes is the most important to price elasticity. In the automobile industry, the major market for lead-acid batteries, there is currently no adequate substitute for the battery, either in its original, new car application or in its battery replacement application. While there are some potential substitutes, these have not as yet proved generally feasible for use. In fact research is being conducted on the development of lead-acid battery powered electric vehicles.

The cost of a battery relative to the total cost of the final product of which it is part is small; e.g. at $40 per battery, the battery price is only .8% of the price of a $5,000 car. If the battery price should double, the price of a car would only increase 0.8%. For these reasons the price elasticity of demand for lead-acid batteries is likely to be inelastic, i.e. a change in price brings about a less-than-proportionate change in sales.

On the whole, when the original equipment and replacement markets are considered together, the price elasticity of demand for lead-acid batteries is likely to be inelastic. The effect of this is that the industry as a whole can pass through the control cost with little effect on sales volume.

However, some smaller plants will not be able to capture all of the cost because they will be competing in the same market as larger plants whose control costs are lower on a per battery basis. For example, while the 6500 BPD plant may be able to recapture all of its control costs, the 2000 BPD plant will be able to capture only a portion of its control costs (the same amount as the larger producer is passing through) in some markets, e.g., the large retail accounts. In those markets where it is shipping to distributors and his competition is similar or smaller size plants, the 2000 BPD plant will be able to pass through the entire cost per battery. The 500 BPD plant will be constrained in the same manner as the smaller plants considered in Section 8.4.4.

8.4.2.4 Price Effects

Long-Run Market Price Response to NSPS

The long-run increase in battery prices resulting from NSPS will be determined by the total incremental unit costs applicable to newly built, economically efficient, production units entering the industry. Over the long-run, industry output can be maintained only through the construction of entirely new plants. The entry and retirement of lead-acid battery plants historically has proceeded at a very slow pace; this long-run adjustment of facilities and operations could take 20 years or more. Over an horizon of 5 to 10 years, adjustment of output will be accomplished primarily by modifications and expansions of existing plants that are, or can become, economically efficient. Since battery production is dominated by the 2000 BPD and larger plants, and since the cost pass-through of smaller plants will be constrained, the medium long-term market price increase will probably be in the \$.30 to \$.40 price per battery range. This represents from 1.6% to 2.2% of the estimated 1976 manufacturer's price of approximately \$18 per auto battery and about 1 to 1.5% of auto battery prices at retail.*

Short-Run Response of Market Price to NSPS

In the short-run, existing battery plants will have to meet only the sulfuric acid mist control standard. The relatively minor long-term battery price increase resulting from NSPS should be mitigated by the gradual pace at which the regulations will become effective. Since the regulations affect existing plants only insofar as they expand, modernize, or replace major equipment items, operating costs will not increase at these plants (as a result of NSPS) until they undertake such investments. Over time, the number and output of plants that have not expanded and replaced equipment will steadily decline. Many of the plants that make replacements will do so on a facility-by-facility basis and thus will incur the incremental NSPS costs gradually. The full price increase attributable to NSPS should become effective only when the total potential output from (a) plants that have not made replacements or expansions in all of their facilities, and (b) new fully reconstructed plants is insufficient to meet the expanding demand for batteries.

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*Estimate obtained from those plants responding to EPA inquiry (Section 114 letters).

8.4.2.5 Growth Effects

The impact on industry growth should not be significant. The 1 to 1.5% increase in price at retail will be effected over a number of years. In the original equipment market the demand for batteries should show little or no decrease and will continue to be primarily dependent on the cyclical nature of the auto industry. In the replacement market demand may be more sensitive to price. Any decrease in smaller company production will be accomodated by expanded production from larger companies. In this way the control costs can be spread over an even larger production. An increase of 1 to 1.5% in the price of a battery will not stimulate faster research into alternative products to the lead-acid battery and it should remain the only feasible product in its many applications for the foreseeable future.

8.4.3 Other Costs

Although the NSPS regulations alone should have a relatively minor impact on battery industry prices and output, their implications are more serious when considered as part of a package of government regulations. The industry either recently has, or shortly will, incur significant additional capital and operating expenditures due to water pollution control, solid waste disposal, new OSHA regulations and lead ambient air regulations. As these expenditures (which generally neither increase output nor reduce manufacturing costs) will all be required of the industry within a few years, the major adverse impacts arising from their cumulative force will be difficult to assess in terms of the individual regulatory components.

The overall impact of these regulations on the industry is likely to be significant. Cumulative annual costs of BAT water pollution costs and solid wastes costs, as shown in Table 8.50 for the 2000 BPD plant, represent 3.1 percent of the estimated 1976 manufacturer's price of $18. Cumulative costs will be significantly higher at plants where current OSHA and SIP regulations are not now being met.

8.4.4 Impact on Small Plants

8.4.4.1 Introduction

As noted earlier in section 8.1, approximately 50 percent of the plants in the lead-acid battery industry produce fewer than 500 BPD. Because small plants are such a large portion of the industry and because small plants are generally affected more severely than large firms, two small plant sizes have been selected, 100 BPD and 250 BPD, for a detailed analysis of the economic impact of both the sulfuric acid mist control costs and the incremental NSPS lead control costs.

Small lead acid battery plants have a number of production and marketing characteristics which distinguish them from larger battery producers. Most of these smaller plants have all of the production capabilities of the larger firms with the exception of lead oxide production and lead reclamation; i.e., these firms have parts casters, grid casters, paste mixers, three process (3-P) operation and formation capability. These firms will be referred to here as "manufacturers". A smaller segment (approximately 31 plants) produces lead acid batteries without the capability of producing and pasting grids. These firms, referred to here as "assemblers", generally have only the 3-P and formation capability. In effect the assemblers purchase all of the parts required for a battery and assemble them into a finished battery.

Another distinguishing characteristic of the small battery producers is the manner in which they form (charge) batteries. There are two processes available for forming the battery: wet formation and dry formation. Few, if any, small plants are dry forming all of their batteries. Most plants which have dry formation also have wet formation capability. The majority of plants have only wet formation capability.

Most independent small firms are one-plant operations and specialize in producing either Starting, Lighting and Ignition (SLI) batteries or industrial batteries, though some plants either allot a small amount of production or purchase for resale the type in whose production they are not specializing. Both SLI and industrial batteries are available in numerous sizes, and industrial batteries are generally larger than SLI batteries. The production processes required to produce SLI and industrial batteries are the same. There are only slight differences in the major pieces of necessary equipment. The distinguishing characteristic is the size of the plates. Industrial batteries require larger plates which are produced by using larger grid casting molds on the casting machine. The amount of paste on the plate may also be greater on some industrial batteries. In some cases industrial batteries are custom-made to meet the client demand and, in such cases, the small firm will also typically service the batteries after sale. The majority of small plants, however, specialize in the production of SLI batteries.

Although the small plants serve several markets, their major market segments are large and small fleet accounts such as bus and truck companies and local government. Sales are also made to warehouse distributors and to off-the-street customers. Different markups are applied to each market segment.

As was seen in Section 8.4.2.4, the average battery price of large producers taken from Section 114 letters was $18 per battery. For small producers the average price used in the calculations which follow is $27. This difference in price is probably explained in the lower production costs of large manufacturers and the fact that smaller plants can receive larger markups because of the markets they serve. Battery distribution is generally performed only regionally and transportation costs prohibit a plant from distributing to larger geographical markets. Small plants deliver to accounts higher up in the marketing chain and deliver directly to their clients so that they receive the entire markup applied to these market segments.

Most industry representatives do not forecast construction of new small plants. Demand will be accommodated from existing plants which replace their facilities. For this reason the economic impact discussion which follows is based on those plants which will reconstruct/modify their existing facilities. Replacement of existing facilities will constitute a reconstruction.

8.4.4.2 Methodology

This section will describe the general methodology used to measure the economic impact on small plants.

The economic impact is evaluated by developing model plants based on representative characteristics of small lead acid battery producers. As will be seen, these characteristics include production capabilities, asset size and other financial characteristics. The models do not represent any particular firm as any individual firm will differ in one or more of these characteristics. The models are meant to provide an indication of the degree of impact on all firms by incorporating in the model the major charcteristics prevailing in this segment of the industry.

Eight model plants are considered here as follows: each of the two model size plants, 100 BPD and 250 BPD, are distinguished by two production capabilities, manufacturing and assembling. A further distinction is made on the basis of the formation capability, i.e., whether the batteries are formed wet or both wet and dry. Dry formation alone is not included because no small plant using dry formation only was identified in field investigations and during interviews with industry representatives.

These distinctions, in addition to plant size, are included in the analysis for two reasons:

- Costs associated with NSPS lead control* will differ between manufacturers and assemblers.
- Costs associated with sulfuric acid mist control will differ between wet and dry forming plants.

Since assemblers do not have casting and pasting capability, no incremental lead control costs are imposed on them for these processes and the economic impact differs between assemblers and manufacturers. Since control costs for sulfuric acid mist will be imposed primarily on dry forming plants,** control costs are higher for these plants and, therefore, the economic impact will differ between plants on this account.

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*Lead control costs are incremental control costs, i.e., costs over and above that required for meeting SIP.

**The recommended standards for formation operations are written for "any formation process which forms before the battery is completely assembled (including installation of battery filler cups) or which forms over a period of less than 24 hours". Most wet formation processes will occur in a period over 24 hours.

The regulatory alternatives under consideration for the lead-acid battery industry include acid mist controls on the dry formation process. Should a standard be promulgated for acid mist emissions under section 111(b) of the Clean Air Act, States would be required to develop standards for acid mist emissions from existing formation processes. For this reason sulfuric acid mist control costs are analyzed individually on existing plants. They are also analyzed with lead NSPS control costs on reconstructed/modified plants because reconstructed/modified plants will also have to meet sulfuric acid mist control in the absence of a specific NSPS for sulfuric acid.

The first step in the analysis requires establishing the total assets of each size plant before the imposition of sulfuric acid mist or lead controls. This result provides "baseline" conditions upon which the return on investment (ROI)* is calculated. Total assets will consist of fixed assets after depreciation and current assets.

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*Defined as (Earnings Before Tax)/(Total Assets); the ROI indicates the investment efficiency of the plant.

The second step estimates the current earnings and profit rate for both manufacturers and assemblers in each of the selected size plants before imposition of the incremental control costs. This procedure is necessary in order to be able to measure the effect of the incremental control costs on earning and, therefore, ROI and the ability of the firm to finance these costs.

The next step uses the total assets from step 1, earnings level from step 2 and the control costs developed in Section 8.2 to determine the ROI before and after incremental control costs are required. This ROI analysis has been conducted for three different scenarios:

- For existing wet/dry forming plants from sulfuric acid mist control alone.
- Lead and sulfuric acid mist control for wet/dry forming reconstructed/modified plants who would be replacing all of their facilities immediately.
- Lead control for wet forming reconstructed/modified plants who would be replacing all of their facilities immediately.

In order to complete this analysis, attention has been given to the fraction of the increase in cost of production due to controls that could be recouped through increased prices (cost pass-through) and the amount that would have to be absorbed. The manner in which the cost pass-through was derived is explained in section 8.4.4.5.

The final step involves the evaluation of the capability of firms to finance the control equipment which is needed to meet the standard. This capability is estimated for two scenarios, a "worst case" situation where no control cost could be passed through, and where a portion of the cost as established in the preceding step could be passed through. This financing capability is based on determining the debt coverage* for each firm after incremental control costs are imposed, i.e., the ability of their annual cash flow** to support repayment of control equipment debt in addition to existing debt repayment.

8.4.4.3 Baseline Economics

Table 8.54 shows the total assets of existing lead-acid battery manufacturing and assembling plants forming by both the wet and dry process. Fixed investment consists of the equipment, land and building required for production in each size and type of plant in addition to OSHA and SIP control equipment. Current values for equipment and building were deflated to 1967 values by use of the Chemical Engineering equipment and machinery index and the Engineering News-Record building index, respectively, to develop historical equipment and building costs.

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*Defined as (Annual Cash Flow)/(Annual Debt Repayment).

**The term cash flow is used as an abbreviation for "net funds inflow from operations". Since we are using earnings before interest and taxes it is not comparable to the traditional use of the term cash flow which is computed by adding depreciation to net earnings without adding back interest expense.

Table 8.54

BASELINE ECONOMICS

CAPITAL INVESTMENT FOR EXISTING LEAD-ACID BATTERY PLANTS

WET AND DRY FORMATION

(In Thousand of Dollars)

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Fixed Investment				
Casting	$ 15.0	$ 24.5	$ -	$ -
Pasting	6.7	10.0	-	-
3-P Process	10.0	11.6	10.0	11.6
Formation	12.5	17.5	12.5	17.5
Land	15.0	20.0	15.0	10.0
Building	68.6	101.8	60.0	98.3
Other Fixed Investment				
OSHA	23.3	26.0	15.8	15.4
SIP - particulates	35.0	35.0	-	-
Total Fixed Investment	$186.1	246.4	113.3	152.8
Accumulated Depreciation[1]	54.1	77.1	32.0	46.0
Fixed Investment After Depreciation	132.0	169.3	81.3	106.8
Current Assets[2]	132.0	169.3	81.3	106.8
Total Assets Before Control	$264.0	$338.6	$162.6	$213.6

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[1] Building at .25 ; process equipment at .66; OSHA, SIP at .133.

[2] At 100% of fixed investment after depreciation.

Deflation of equipment and building values was necessary because existing plants whose facilities had been purchased in the past were analyzed and current depreciation is dependent on this historical purchase price. Accumulated depreciation was subtracted to derive fixed investment after depreciation. Accumulated depreciation is based on process equipment being depreciated by 66%, building by 25% and OSHA and SIP equipment by 13.3%. Only the major pieces of equipment were included in the asset base. The process equipment in this industry has a long useful life span, 25 to 30 years or more.

Many plants visited had fully depreciated their equipment while others had newer equipment, i.e., less than 10 years old. The average age of equipment was taken to be 10 years old and depreciated at 6.6% per year to yield accumulated depreciation of 66%. The age of the building tends to vary greatly from plant to plant and the 25% rate, used as representative of the industry, is based on a 10 year old building being depreciated at 2.5% per year. OSHA and SIP control equipment is assumed to have been put in place two years ago so that with a useful life of 15 years 13.3% of the cost is depreciated.

In the ROI analysis that follows, ROI before control appears high relative to other industries. This stems from two factors: the first is characteristic of the industry, the second is dependent on the manner in which models are constructed. Small plant production is labor intensive relative to the amount of capital required for production. This labor intensity can be shown by the labor cost per battery relative to depreciation cost per battery. Figures which were developed during this analysis show a relationship of labor cost to capital cost per battery of approximately 10 to 1. Even if capital costs were doubled so that a 5 to 1 ratio prevailed this would still indicate labor intensity. Because of the high value added by labor, ROI will tend to be high relative to industries where larger capital requirements are necessary for production. The second reason for these seemingly high ROI figures arises from the small total asset base (ROI = net earnings/total assets) which was used. Our model asset parameters include only the major pieces of equipment and plant required for production. Ancillary equipment such as fork lift trucks, delivery trucks, office furniture, and minor pieces of equipment such as a number of different sized casting molds were excluded. Also excluded were additional warehouse space which a number of larger small plants have in different locations. For these reasons the asset base is low and the ROI developed is high relative to what would be shown if a complete inventory of fixed assets were included. This qualification does not negate the impact which will be shown in the following analysis.

In order to derive total assets, current assets had to be added to fixed assets after depreciation. Current assets are based on 100% of fixed assets after depreciation. While this rate cannot be as fully substantiated as the other rates, one firm visited has current assets of 135% of fixed assets after depreciation but the building was carried as a personal asset of the owner.

Table 8.55 shows the baseline economics for plants with only wet formation capability and is constructed in the same manner as Table 8.54. The principal difference in Table 8.55 from Table 8.54 is fixed investment in formation equipment. Wet forming requires less investment in equipment than wet and dry forming together. Accumulated depreciation is therefore changed as are current assets. The total assets before control for wet forming plants is shown in the last row of Table 8.55. Both current OSHA and SIP investment costs are assumed fully in place and are included in the total asset base.

8.4.4.4 Estimated Earnings Before Control

Tables 8.56 and 8.57 indicate, for manufacturing and assembling plants, respectively, the estimated earnings before imposition of sulfuric acid mist and lead incremental control costs. In these tables, revenue is based on an operating rate of 80% and a battery price of $27. The operating rate is based on information supplied through interviews with plant owners, and varies from 50 to 100%. The battery price is calculated from a price list of 23 types of SLI batteries supplied by a firm to different market segments such as warehouses, fleets and off-the-street sales. Since prices vary by market segment

Table 8.55

BASELINE ECONOMICS

CAPITAL INVESTMENT FOR EXISTING LEAD-ACID BATTERY PLANTS

WET FORMATION ONLY

(In Thousand of Dollars)

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Fixed Investment				
Casting	$ 15.0	$ 24.5	$ -	$ -
Pasting	6.7	10.0	-	-
3-P Process	10.0	11.6	10.0	11.6
Formation	5.0	7.5	5.0	7.5
Land	15.0	20.0	15.0	20.0
Building	68.5	106.8	60.0	98.3
Other Fixed Investment				
OSHA	23.3	26.0	15.8	15.4
SIP - particulates	35.0	35.0	-	-
Total Fixed Investment	$178.5	241.4	105.8	152.8
Accumulated Depreciation[1]	49.3	60.1	26.0	39.2
Fixed Investment After Depreciation	129.2	181.3	79.8	113.6
Current Assets[2]	129.2	181.3	79.8	113.6
Total Assets Before Control	$258.4	$362.6	$159.6	$227.2

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[1] Building at .25; process equipment at .66 ; OSHA, SIP at .133.

[2] At 100% of fixed investment after depreciation.

Table 8.56

ESTIMATED FINANCIAL DATA

for

SMALL LEAD-ACID BATTERY MANUFACTURING PLANTS[1]

BEFORE NSPS LEAD AND SULFURIC ACID MIST CONTROLS

	Model Plant Size	
	100 BPD	250 BPD
Revenue[2]	$540,000	$1,350,000
Operating Expenses	$470,400	$1,168,500
Earnings Before Taxes	$ 69,600	$ 181,500
Earnings Rate Before Taxes	12.9%	13.4%
Taxes[3]	$ 20,400	$ 74,100
Earnings After Taxes	$ 49,200	$ 107,400
Earnings Rate After Taxes	9.1%	8.0%

[1] For Wet and Wet/Dry Formation.

[2] Based on operating rate of 80% and battery price of $27.00 per battery.

[3] Calculated at 22% of first $50,000 and 48% on remainder of earnings before taxes rather than at official rate of 20% of first $25,000, 22% of next $25,000 and 48% of remainder over $50,000.

Table 8.57

ESTIMATED FINANCIAL DATA

for

SMALL LEAD-ACID BATTERY ASSEMBLING PLANTS[1]

BEFORE NSPS LEAD AND SULFURIC ACID MIST CONTROLS

	Model Plant Size	
	100 BPD	250 BPD
Revenue[2]	$540,000	$1,350,000
Operating Expenses	$487,400	$1,215,500
Earnings Before Taxes	$ 52,600	$ 134,500
Earnings Rate Before Taxes	9.7%	10.0%
Taxes[3]	$ 12,200	$ 51,600
Earnings After Taxes	$ 40,400	$ 82,900
Earnings Rate After Taxes	7.5%	6.1%

[1] For Wet and Wet/Dry Formation.

[2] Based on operating rate of 80% and battery price of $27.00 per battery.

[3] Calculated at 22% of first $50,000 and 48% on remainder of earnings before taxes rather than at official rate of 20% of first $25,000, 22% of next $25,000 and 48% of remainder over $50,000.

due to the discount/markup structure, an average price for different types of batteries sold to each market segment was developed. This price was then weighted by the corresponding share of the market segment to derive a weighted average price of SLI batteries for small plants.

Operating expenses have been calculated from information supplied at various interviews. Cost of production is derived from data such as the amount of lead necesary for each part, miscellaneous supplies such as battery cases, labor manhours per battery and wage rates provided during interviews. Delivery and utility costs are included and plant and equipment depreciation determined from the baseline economics. Plant was depreciated at the rate of 2.5% per year and equipment at 6.6% per year. An overhead charge of 40% of labor cost is also included. Earnings before taxes is the difference between revenue and operating expenses. Applicable Federal tax rates are used to derive earnings after taxes. The percent earnings before tax are in the range of 8 to 15% which are supported by data obtained during field interviews.

8.4.4.5 Return on Investment (ROI) Impact

As discussed in Section 8.4.4.1 sulfuric acid mist control will affect all plants doing any dry forming of batteries. Table 8.58 shows the decline in ROI from sulfuric acid mist control on those small plants doing a combination of wet and dry forming. Data included in Table 8.58 are derived as follows: Earnings before tax is taken from Tables 8.56 and 8.57

Table 8.58

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Existing
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets	$264.0	$338.6	$162.6	$213.6
ROI Before Control	26.4%	53.5%	32.3%	62.9%
Total Annualized Control Cost	$ 9.0	$ 14.7	$ 9.0	$ 14.7
Control Cost Per Battery[1]	$ .45	$ .29	$ .45	$ .29
Cost Pass Through	$ .26	$ .26	$ .26	$ .26
Earnings Before Tax and After Control[2]	$ 65.8	$180.0	$ 48.8	$133.0
Total Assets After Control	$278.4	$368.6	$177.0	$243.6
ROI After Control	23.6%	48.8%	27.6%	54.6%

[1] At 80% operating rate.

[2] After total annualized control cost absorbed subtracted.

and total assets from Table 8.54. The annual sulfuric acid mist control cost is taken from Table 8.43 and is divided by the number of batteries produced at an 80% operating rate (250 working days per year is used in calculating annual production) to yield control cost per battery. The cost pass-through per battery, which will be developed further below, is determined in Table 8.59.

Earnings before tax and after control is determined by subtracting total annualized control cost absorbed from earnings before control. In the case of the 100 BPD manufacturer, $0.19 per battery is absorbed ($0.45-$0.26) or $3,800 so that earnings before control is reduced by $3,800 ($65,800 = $69,600 - $3,800).

Table 8.59 presents the derivation of the cost pass-through of $0.26 per battery after sulfuric acid mist controls. Because there are few adequate substitutes for lead-acid batteries in the SLI category, the industry as a whole should be able to pass on part or all of the control cost which it has to incur without a significant impact to its earnings potential. However, the smaller operations must compete with larger companies in various markets. Because control cost is lower for larger producers the small operators cannot pass on the entire amount of their cost increase without incurring losses in their market segments.

Table 8.51 in Section 8.4.2.2 showed the sulfuric acid mist control cost per battery at capacity and at an 80% operating rate for the 500, 2000 and 6500 BPD manufacturer. The

Table 8.59

COST PASS-THROUGH PER BATTERY

SULFURIC ACID MIST CONTROL ONLY

EXISTING PLANTS

Description of Market	Large Plant Price Increase	Markup With Respect to Warehouse, Charged by Small Plant	Distribution of Small Plant Sales By Market	Partial Pass Through By Market
• Warehouse	$.20	--	.1	$.02
• Large Fleets	.20	1.25	.4	.10
• Small Fleets	.20	1.33	.4	.11
• Off-the-Street Retail	.20	1.45	.1	.03
Total Average Cost Pass Through per Battery				$.26

main cost pass-through restraint to the small producer is taken to be the manufacturer in the 2000 BPD area. The 6500 BPD operator is generally selling to the large OEM markets and to large retail accounts. A $.20 per battery cost pass-through is assumed which is slightly larger than the 2000 BPD operator's at an 80% operating rate.

The major market for the smaller battery companies, including the 500 BPD operator, are fleet accounts. In this market, the small plants are faced with competition from the larger producers, i.e., through warehouse distributors who handle the larger companies' batteries and market them to fleet accounts. Therefore the control cost which the larger producers incur is inflated in the battery price to fleet accounts by the distributors' markup. Although price competition prevails, there are significant non-price reasons, (such as faster delivery time, better credit arrangements and ability to service the batteries) for the fleet account's preference for the small plant.

The small firms can then pass through $.20 per battery to their lowest price client, which is the warehouse. But since the market share to this market is only 10% of production, the control cost captured is only $.02 per battery taken over all production. The market shares are meant to represent the model plant's distribution of sales to various market segments. As can be seen the bulk of sales is to the fleet accounts. From the warehouse price the small plant will generally markup his price 25% to large fleet accounts or $0.25. Therefore, with 40% of sales going to this account $0.10 per battery of the control cost is captured taken over all production.

With these various market shares and markups, the small operator can recapture an estimated $0.26 of the $0.45 per battery control cost.

The 100 BPD manufacturer and assembler must therefore absorb $0.19 per battery of the sulfuric acid mist control cost and the 250 BPD manufacturer and assembler $0.03 per battery. Table 8.58 shows that ROI declines after control. For both manufacturer and asembler this decline is not substantial with sulfuric acid mist control alone.

Table 8.60 shows the ROI impact of both sulfuric acid mist control and NSPS lead control if the operators replace all of the affected facilities immediately after the standards are promulgated. The total assets with new investment are determined from Table 8.54 by adding total assets before control to new investment in process equipment. New investment cost is based on the current market price of the process equipment for the affected facilities: casting, pasting, three process (3-P) operation, and formation. The annual control cost is taken from Table 8-38, Alternative VI for lead and Table 8-43 for sulfuric acid mist control.

The combination of NSPS lead and sulfuric acid mist control costs increase the control cost per battery substantially from sulfuric acid mist control alone. The cost pass-

Table 8.60

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets	$352.6	$465.9	$207.7	$271.9
ROI Before Control	19.7%	39.0%	25.3%	49.5%
Total Annualized Control Cost	$ 41.8	$ 49.6	$ 40.2	$ 47.7
Control Cost Per Battery[1]	$ 2.09	$ .99	$ 2.01	$ .95
Cost Pass Through	$ .574	$ .574	$ .574	$ .574
Earnings Before Tax and After Control[2]	$ 33.4	$152.2	$ 20.9	$111.8
Total Assets After Control	$474.0	$609.9	$324.1	$409.9
ROI After Control	7.0%	25.0%	6.4%	27.2%

[1] At 80% operating rate.

[2] After control cost absorbed and equipment depreciation subtracted.

through per battery under this condition, calculated in Table 8.61, is taken from Table 8.52 and is slightly above the cost per battery for the 2000 BPD plant at an 80% operating rate. The manner in which effective cost pass-through is determined in Table 8.61 is the same as that used above in Table 8.59, i.e., by market-segment analysis. The cost pass-through for Table 8.61 is used in Table 8.60 to calculate earnings impact after controls due to absorbed costs. The ROI declines for all situations analyzed in Table 8.60 for NSPS lead and sulfuric acid mist controls taken together show a range of from 12 to 22 percent.

Table 8.62 indicates the ROI impact on small plants forming batteries by the wet process only. These plants would incur only NSPS lead control. Annual control cost in Table 8.62 is taken from Table 8.38. Other entries are derived in a manner similar to that described above for Tables 8.58 and 8.60. Immediate replacement of all of their affected facilities after the initiation of the standard would decrease the ROI by 10 to 11 percentage points for manufacturers and by 16 to 17 percentage points for assemblers.

As Table 8.58 indicates, all existing wet/dry forming plants should be able to meet the sulfuric acid mist control standard without incurring severe economic impacts. Declines in ROI range from 3 to 8 percentage points and the resulting ROI after control is sufficiently high relative to alternative investment opportunities to permit continued operation in the industry.

Table 8.61

COST PASS-THROUGH PER BATTERY

SULFURIC ACID MIST AND NSPS LEAD CONTROLS

EXISTING PLANTS

Description of Market	Large Plant Price Increase	Markup With Respect to Warehouse, Charged by Small Plant	Distribution of Small Plant Sales By Market	Partial Pass Through By Market
• Warehouse	$.45	--	.1	$.045
• Large Fleets	.45	1.25	.4	.225
• Small Fleets	.45	1.33	.4	.239
• Off-the-Street Retail	.45	1.45	.1	.065
Total Average Cost Pass Through per Battery				$.574

Table 8.62

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets	$332.0	$469.9	$189.7	$265.5
ROI Before Control	21.0%	38.6%	27.7%	50.7%
Total Annualized Control Cost	$ 32.8	$ 34.9	$ 31.2	$ 33.0
Control Cost Per Battery[1]	$ 1.64	$ .70	$ 1.56	$ .66
Cost Pass Through	$ .574	$ .574	$ .574	$ .574
Earnings Before Tax and After Control[2]	$ 43.4	$168.0	$ 30.9	$127.6
Total Assets After Control	$439.0	$583.9	$291.7	$373.5
ROI After Control	9.9%	28.7%	10.5%	34.1%

[1] At 80% operating rate.

[2] After control cost absorbed and equipment depreciation subtracted.

Although most small plants are using only the wet forming process, there will be certain cases where a wet forming small plant is competing in the same area as a wet/dry forming small plant. In this case the wet forming plant will have a competitive advantage over the wet/dry forming plant.

The wet/dry forming plant operator may have to decide whether to completely absorb the contol cost or to discontinue dry forming. To completely absorb the control cost will decrease ROI another 2.0%, from 23.6% to 21.7% for the 100 BPD manufacturer. Since dry forming is likely to be a minor portion of battery production,* the more likely alternative may be to discontinue dry forming production.

8.4.4.6 Control Equipment Financing Capability

This section presents an analysis of the potential ability of plants to obtain financing for the required control equipment necessary to meet the standards. The analysis is based on the debt coverage ratio which shows the ability of annual cash flows to repay existing and new debt incurred. Debt coverage is an objective means of determining a firm's ability to repay a loan, but financial institutions also look at management capability, long-term relationship between the company and the financial institution, etc. These evaluations can only be made on a case-by-case basis and cannot be analyzed here.

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*In the few plants where this combination was observed, dry forming ranged from 10% to 30% of production.

In Table 8.63 Earnings Before Interest and Taxes (EBIT) after control is derived by taking the earnings before tax figure from Tables 8.56 and 8.57 and adding back interest on existing debt and new process equipment debt, where applicable. Annual control cost exclusive of interest is then subtracted. Since existing debt is composed of both long term liabilities of a year or longer (in most cases 5 to 20 year duration) and short term debt of a term less than a year, interest on existing debt was calculated by using a 10% interest rate on debt of an average 10 year duration, a capital recovery factor [CRF] of .16275. Interest on control equipment was based on a CRF of .132, 10% interest over 15 years. The annual interest used was the annual average over the term of the loan. Depreciation is the sum of annual depreciation of the building and process equipment, added to annual depreciation of the control equipment. Annual cash flow is the summation of EBIT and depreciation.

Annual debt repayment consists of debt items which must be paid from company funds - principal and interest for existing control equipment and new process equipment debt, where applicable. The annual interest and principal are taken as the annual average over the term of the debt. The principal for each category was converted to the pretax amount which is needed to yield an after-tax outlay equal to the fixed charge for each category of debt.* This was required in

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*The tax rate used was the effective tax rate as calculated from Tables 8.56 and 8.57.

Table 8.63

FINANCIAL CAPABILITY ANALYSIS OF SMALL LEAD-ACID BATTERY PLANTS ASSUMING NO COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Existing
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 71.3	$179.4	$ 50.7	$128.4
Depreciation After Control[1]	$ 8.1	13.5	5.5	9.9
Annual Cash Flow	79.4	192.9	56.2	138.3
Total Assets	$264.0	$338.6	$162.6	213.6
Debt Obligations Before Control[2]	132.0	169.3	81.3	103.6
Annual Debt Repayment[3]				
Existing Debt	26.4	39.7	23.5	23.3
Control Equipment Debt	2.2	5.2	2.2	5.1
Total Annual Debt Repayment	28.6	44.9	25.7	28.4
Debt Coverage[4]	2.8	4.3	2.2	4.9

[1] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[2] At 50% of total assets before controls.

[3] CRF = 0.16275 for existing debt; = 0.132 for control equipment debt.

[4] Annual cash flow/total annual debt repayment.

order to bring it to a basis comparable to that of the tax deductible fixed charges. Annual interest for each category is then added to the converted principal amount, summed for each category and compared to cash flow to determine the adequacy of cash flow to cover the debt repayment.

As Table 8.63 shows annual cash flow for all size plants for sulfuric acid mist control in the "worst case"* situation is adequate to support both existing debt and control equipment debt repayment.

Table 8.64 presents the financial capability of reconstructed/modified plants to support both sulfuric acid mist and NSPS lead control costs in the worst case situation. In this scenario plants must not only be able to support existing and control equipment debt repayment but also new process equipment debt repayment which engenders the lead control costs. New equipment debt is based on 100% financing of the affected process facilities. New equipment debt is based on a CRF of .132, 10% interest over 15 years. For this scenario the annual cash flow is barely sufficient to cover debt repayment for both the 100 BPD manufacturer and assembler. Financial institutions would not be very likely to grant financing of the control equipment under these conditions, and the plant would have to look elsewhere such as the Small Business Administration for financing.

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*Described here as without any cost pass-through.

Table 8.64

FINANCIAL CAPABILITY ANALYSIS
OF SMALL LEAD-ACID BATTERY PLANTS
ASSUMING NO COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 53.8	$160.1	$ 30.9	$108.1
Depreciation After Control[1]	$ 19.3	24.6	13.2	16.2
Annual Cash Flow	73.1	184.7	44.1	124.3
Total Assets with New Investment	$352.6	$465.9	$207.7	$271.9
Debt Obligations Before Control	221.0	296.6	126.4	158.6
Existing Debt[2]	132.4	169.3	81.3	103.6
New Equipment Debt[3]	88.6	127.3	45.1	55.0
Annual Debt Repayment[4]				
Existing Debt	26.6	39.7	15.6	23.3
New Equipment Debt	13.7	17.7	6.7	9.2
Control Equipment Debt	18.3	23.4	17.6	22.7
Total Annual Debt Repayment	58.6	80.8	39.9	55.2
Debt Coverage[5]	1.2	2.3	1.1	2.3

[1] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[2] At 50% of total assets before new investment, same as Table 8.54.

[3] At 100% financing.

[4] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.

[5] Annual cash flow/total annual debt repayment.

Debt coverage for reconstructed/modified wet formation plants is improved when NSPS lead controls are considered alone (Table 8.65). Nevertheless, both the 100 BPD manufacturer and assembler will still be unlikely to finance the new process and control equipment.

No financial capability analysis was performed for sulfuric acid mist controls alone with partial cost pass-through because in the worst case situation (as depicted in Table 8.63) the cash flow was sufficient to support debt repayment. The analysis performed for sulfuric acid mist and NSPS lead controls together (Table 8.66) and NSPS lead controls alone (Table 8.67) with partial cost pass-through shows that both the 100 BPD manufacturer and assembler would still have a difficult time in obtaining financing based on consideration of debt coverage ratios alone.

In the "worst case" situation, sulfuric acid mist control equipment financing should be possible for all existing plants, even if all the control cost must be absorbed. The 250 BPD plants should be able even in the worst case situation to obtain financing from financial institutions. Their debt coverage is sufficient to allow institutions to grant financing.

The 100 BPD plants are not likely to be able to obtain financing in the worst case situations. With partial cost pass-through of $.574 per battery financing should still prove difficult, particularly so for the plants incurring

Table 8.65

FINANCIAL CAPABILITY ANALYSIS
OF SMALL LEAD-ACID BATTERY PLANTS
ASSUMING NO COST PASS-THROUGH

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 59.9	$175.4	$ 37.2	$120.8
Depreciation After Control[1]	$ 17.4	21.3	11.2	13.1
Annual Cash Flow	77.3	196.7	48.4	133.9
Total Assets with New Investment	$332.0	$469.9	$189.7	$265.5
Debt Obligations Before Control	213.2	288.6	109.9	151.9
Existing Debt[2]	139.6	181.3	79.8	113.6
New Equipment Debt[3]	73.6	107.3	30.1	38.3
Annual Debt Repayment[4]				
Existing Debt	28.3	41.4	16.9	25.0
New Equipment Debt	11.5	18.5	4.6	6.3
Control Equipment Debt	16.3	19.4	15.2	18.0
Total Annual Debt Repayment	56.1	79.3	36.7	49.3
Debt Coverage[5]	1.4	2.5	1.3	2.7

[1] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[2] At 50% of total assets before control, same as Table 8.55.

[3] At 100% financing.

[4] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.

[5] Annual cash flow/total annual debt repayment.

Table 8.66

FINANCIAL CAPABILITY ANALYSIS OF SMALL LEAD-ACID BATTERY PLANTS WITH PARTIAL COST PASS-THROUGH[1]

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 65.3	$189.8	$ 41.9	$136.8
Depreciation After Control[2]	$ 19.3	24.6	13.2	16.2
Annual Cash Flow	85.6	214.4	55.1	153.0
Total Assets with New Investment	$352.6	$465.9	$207.7	$271.9
Debt Obligations Before Control	220.4	296.6	126.5	159.3
Existing Debt[3]	131.8	169.3	81.3	103.6
New Equipment Debt[4]	88.6	127.3	45.1	55.7
Annual Debt Repayment[5]				
Existing Debt	26.6	39.7	15.6	23.3
New Equipment Debt	13.7	17.7	6.7	9.2
Control Equipment Debt	18.3	23.4	17.6	22.7
Total Annual Debt Repayment	58.6	80.8	39.9	55.2
Debt Coverage[6]	1.5	2.7	1.4	2.8

[1] Cost pass through of $.574 per battery.
[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.
[3] At 50% of total assets before control, same as Table 8.54.
[4] At 100% financing.
[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.
[6] Annual cash flow/total annual debt repayment.

Table 8.67

FINANCIAL CAPABILITY ANALYSIS OF SMALL LEAD-ACID BATTERY PLANTS WITH PARTIAL COST PASS-THROUGH[1]

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 71.4	$204.1	$ 48.7	$149.5
Depreciation After Control[2]	$ 17.4	21.3	11.2	13.1
Annual Cash Flow	88.8	223.4	59.9	162.6
Total Assets with New Investment	$332.0	$469.9	$189.7	$265.5
Debt Obligations Before Control	213.2	288.6	109.9	151.9
Existing Debt[3]	139.6	181.3	79.8	113.6
New Equipment Debt[4]	73.6	107.3	30.1	38.3
Annual Debt Repayment[5]				
Existing Debt	28.3	41.4	16.9	25.0
New Equipment Debt	11.5	18.5	4.6	6.3
Control Equipment Debt	16.3	19.4	15.2	18.0
Total Annual Debt Repayment	56.1	79.3	36.7	49.3
Debt Coverage[6]	1.6	2.8	1.6	3.3

[1] Cost pass through of $.574 per battery.
[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.
[3] At 50% of total assets before control, same as Table 8.55.
[4] At 100% financing.
[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.
[6] Annual cash flow/total annual debt repayment.

both sulfuric acid mist and lead NSPS control costs. In the latter case it is likely that the wet/dry forming plant may consider discontinuing dry formation as this would enhance debt coverage and possible ability to finance the lead control equipment.

The preceding analysis was based on an operating rate of 80 percent. If conditions for individual 100 BPD plants should allow them to operate closer to capacity, their debt coverage would be improved, though not substantially.

For both sulfuric acid mist and lead control together or lead control alone, obtaining financing is still problematic for the 100 BPD plant.

8.4.4.7 Compliance Testing Costs

Sulfuric acid mist and lead particulate compliance testing costs for manufacturers and assemblers are shown in Table 8.68. Tables 8.69 to 8.76 show the ROI impact and financing capability for existing and reconstructed/ modified plants when compliance testing cost is considered in addition to the equipment control cost.

The testing costs were assumed to be 100 percent financed at 10 percent interest over 7 years. The CRF of .20541 was then applied to determine the annualized cost for testing. This cost was applied to the ROI and financial capability tables exclusive of testing costs.

As can be seen in the Summary table in section 8.4.4.9, testing costs aggravate the impacts facing all size plants.

The 100 BPD manufacturers and assemblers facing both sulfuric acid mist and NSPS lead control or NSPS lead control alone experience an even lower ROI. Their ability to finance control equipment and testing costs together is further deteriorated.

Table 8.66

COMPLIANCE TESTING ANNUALIZED COSTS

SMALL PLANTS

Plant Description	Testing Costs[1]
Sulfuric Acid Mist	
(Wet/Dry Existing)	
Manufacturing	$11,500
Assembling	$11,500
Sulfuric Acid Mist and NSPS Lead	
(Wet/Dry Reconstructed)	
Manufacturing	$23,500
Assembling	$17,500
NSPS Lead	
(Wet Reconstructed)	
Manufacturing	$13,500
Assembling	$ 7,500

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[1] Costs are independent of plant size but depend on emission being tested and number of stacks tested.

Table 8.69

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Existing
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets	$264.0	$338.6	$162.6	$213.6
ROI Before Control	26.4%	53.6%	32.3%	63.0%
Total Annualized Control Cost	$ 11.4	$ 17.1	$ 11.4	$ 17.1
Control Cost Per Battery[1]	$ .57	$ .34	$ .57	$ .34
Cost Pass Through	$ .26	$ .26	$ .26	$ .26
Earnings Before Tax and After Control[2]	$ 63.4	$177.5	$ 46.4	$130.5
Total Assets After Control	$278.4	$368.6	$177.0	$243.6
ROI After Control	22.7%	48.1%	26.2%	53.6%

[1] At 80% operating rate.

[2] After control cost and testing cost absorbed and equipment depreciation subtracted.

Table 8.70

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets	$352.6	$465.9	$207.7	$271.9
ROI Before Control	19.8%	39.0%	25.3%	49.5%
Total Annualized Control Cost	$ 46.6	$ 54.6	$ 43.8	$ 51.7
Control Cost Per Battery[1]	$ 2.33	$ 1.09	$ 2.19	$ 1.03
Cost Pass Through	$ .574	$ .574	$ .574	$ .574
Earnings Before Tax and After Control[2]	$ 28.6	$147.2	$ 17.3	$107.8
Total Assets After Control	$474.0	$609.9	$324.1	$409.9
ROI After Control	6.0%	24.1%	5.3%	26.3%

[1] At 80% operating rate.

[2] After control cost and testing cost absorbed and equipment depreciation subtracted.

Table 8.71

RETURN ON INVESTMENT IMPACT

SMALL LEAD-ACID BATTERY PLANTS

COST PASS-THROUGH

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
Earnings Before Tax	$ 69.6	$181.5	$ 52.6	$134.5
Total Assets with New investments	$332.0	$469.9	$189.7	$265.5
ROI Before Control	21.0%	38.6%	27.7%	50.7%
Total Annualized Control Cost	$ 35.6	$ 37.4	$ 32.7	$ 34.5
Control Cost Per Battery[1]	$ 1.78	$ .75	$ 1.64	$ .69
Cost Pass Through	$ .574	$ .574	$ .574	$ .574
Earnings Before Tax and After Control[2]	$ 40.6	$165.5	$ 29.3	$126.1
Total Assets After Control	$439.0	$583.9	$291.7	$373.5
ROI After Control	9.2%	28.3%	10.0%	33.7%

[1] At 80% operating rate.

[2] After control cost and testing cost absorbed and equipment depreciation subtracted.

Table 8.72

FINANCIAL CAPABILITY ANALYSIS

OF SMALL LEAD-ACID BATTERY PLANTS

WORST CASE SITUATION[1]

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Existing
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 69.7	$177.8	$ 49.1	$126.8
Depreciation After Control[2]	$ 8.1	13.5	5.5	9.9
Annual Cash Flow	77.8	191.3	54.6	136.7
Total Assets	$264.0	$338.6	$162.6	$213.6
Debt Obligations Before Control[3]	132.4	169.3	81.3	103.6
Annual Debt Repayment[4]				
Existing Debt	26.4	39.7	23.5	23.3
Control Equipment Debt	5.3	8.7	5.1	8.5
Total Annual Debt Repayment	31.7	48.4	28.6	31.8
Debt Coverage[5]	2.5	4.0	1.9	4.3

[1] Assuming no cost pass-through.
[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.
[3] At 50% of total assets before control, same as Table 8.55.
[4] CRF = 0.16275 for existing debt; = 0.132 for control equipment debt.
[5] Annual cash flow/total annual debt repayment.

Table 8.73

FINANCIAL CAPABILITY ANALYSIS

OF SMALL LEAD-ACID BATTERY PLANTS

WORST CASE SITUATION[1]

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant Reconstructed/Modified
Type of Formation Wet and Dry
Type of Control Sulfuric Acid Mist and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 50.5	$156.8	$ 28.5	$105.7
Depreciation After Control[2]	$ 19.3	24.6	13.2	16.2
Annual Cash Flow	69.8	181.4	41.7	121.9
Total Assets with New Investment	$352.6	$465.9	$207.7	$271.9
Debt Obligations Before Control	220.4	296.6	126.4	158.6
Existing Debt[3]	131.8	169.3	81.3	103.6
New Equipment Debt[4]	88.6	127.3	45.1	55.0
Annual Debt Repayment[5]				
Existing Debt	26.6	39.7	15.6	23.3
New Equipment Debt	13.7	17.7	6.7	9.2
Control Equipment Debt	24.4	30.5	22.0	27.8
Total Annual Debt Repayment	64.7	87.9	44.3	60.3
Debt Coverage[6]	1.1	2.1	0.9	2.0

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[1] Assuming no cost pass-through.

[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[3] At 50% of total assets before control, same as Table 8.55.

[4] At 100% financing.

[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.

[6] Annual cash flow/total annual debt repayment.

Table 8.74

FINANCIAL CAPABILITY ANALYSIS

OF SMALL LEAD-ACID BATTERY PLANTS

WORST CASE SITUATION[1]

TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 58.0	$173.5	$ 36.2	$119.8
Depreciation After Control[2]	$ 17.4	21.3	11.2	13.1
Annual Cash Flow	75.4	194.8	47.4	132.9
Total Assets with New Investment	$332.0	$469.9	$189.7	$265.5
Debt Obligations Before Control	213.2	288.6	109.9	151.9
Existing Debt[3]	139.6	181.3	79.8	113.6
New Equipment Debt[4]	73.6	107.3	30.1	38.3
Annual Debt Repayment[5]				
Existing Debt	28.3	41.4	16.9	25.0
New Equipment Debt	11.5	18.5	4.6	6.3
Control Equipment Debt	24.4	30.5	22.0	27.8
Total Annual Debt Repayment	64.2	90.4	43.5	59.1
Debt Coverage[6]	1.2	2.2	1.1	2.2

[1] Assuming no cost pass-through.

[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[3] At 50% of total assets before control, same as Table 8.55.

[4] At 100% financing.

[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.

[6] Annual cash flow/total annual debt repayment.

Table 8.75

FINANCIAL CAPABILITY ANALYSIS OF SMALL LEAD-ACID BATTERY PLANTS WITH PARTIAL COST PASS-THROUGH[1] TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet and Dry
Type of Control	Sulfuric Acid Mist and NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 62.0	$186.5	$ 39.5	$134.4
Depreciation After Control[2]	$ 19.3	24.6	13.2	16.2
Annual Cash Flow	81.3	211.1	52.7	150.6
Total Assets with New Investment	$352.6	$465.9	$207.7	$271.9
Debt Obligations Before Control	220.4	296.6	126.4	159.3
Existing Debt[3]	131.8	169.3	81.3	103.6
New Equipment Debt[4]	88.6	127.3	45.1	55.7
Annual Debt Repayment[5]				
Existing Debt	26.6	39.6	15.6	23.3
New Equipment Debt	13.7	17.7	6.7	9.2
Control Equipment Debt	24.4	30.5	22.0	27.8
Total Annual Debt Repayment	64.7	87.8	44.3	60.3
Debt Coverage[6]	1.3	2.4	1.2	2.5

[1] Cost pass through of $.574 per battery.
[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.
[3] At 50% of total assets before control, same as Table 8.55.
[4] At 100% financing.
[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.
[6] Annual cash flow/total annual debt repayment.

Table 8.76

FINANCIAL CAPABILITY ANALYSIS OF SMALL LEAD-ACID BATTERY PLANTS WITH PARTIAL COST PASS-THROUGH[1] TESTING COST INCLUDED

(In Thousand of Dollars)

Type of Plant	Reconstructed/Modified
Type of Formation	Wet
Type of Control	NSPS Lead

	Manufacturing		Assembling	
	100 BPD	250 BPD	100 BPD	250 BPD
EBIT After Control	$ 69.5	$202.2	$ 47.7	$148.5
Depreciation After Control[2]	$ 17.4	21.3	11.2	13.1
Annual Cash Flow	86.9	223.5	58.9	161.6
Total Assets with New Investment	$332.0	$469.9	$189.7	$265.5
Debt Obligations Before Control	213.2	288.6	109.9	151.9
Existing Debt[3]	139.6	181.3	79.8	113.6
New Equipment Debt[4]	73.6	107.3	30.1	38.3
Annual Debt Repayment[5]				
Existing Debt	28.3	41.4	16.9	25.0
New Equipment Debt	11.5	18.5	4.6	6.3
Control Equipment Debt	19.6	23.2	17.0	20.1
Total Annual Debt Repayment	59.4	83.1	38.5	51.4
Debt Coverage[6]	1.5	2.7	1.5	3.1

[1] Cost pass through of $.574 per battery.

[2] Building at .025; equipment at .066; OSHA, SIP and new control equipment at .066.

[3] At 50% of total assets before control, same as Table 8.55.

[4] At 100% financing.

[5] CRF = 0.16275 for existing debt; = 0.132 for new equipment and control equipment debt.

[6] Annual cash flow/total annual debt repayment.

8.4.4.8 Other Cost Considerations

Not considered in the previous analysis were solid waste costs, water pollution costs and costs associated with meeting the recently established Occupational Safety and Health Administration's (OSHA) 50 $\mu g/m^3$ lead-inair standard. All of these costs will have to be met in the future.

Annual solid waste costs are given in Tables 8.45 and 8.46. Plants discharging wastewater to navigable waters will be subject to effluent limitations when these are promulgated. However, most plants are located in urban areas, and are probably discharging to municipal sewers. The majority of plants will, therefore, be subject to pretreatment standards.

The pretreatment standard is expected to be the same as the BPT standard. Table 8.77 compares the control cost estimated to meet the BPT standards* (which should be similar to pretreatment costs) and the control cost required to meet the NSPS lead control standard. The pretreatment cost for assemblers would be the same as shown for manufacturers. As can be seen these costs approach and, in the case of the 250 BPD wet/dry plant, exceed the lead control costs. No cost estimate is available for meeting the 50 $\mu g/m^3$ OSHA standard in the lead acid battery industry.

When these anticipated costs are imposed on small plants the effects shown for the 100 BPD operator will be aggravated.

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*Costs for wet forming plants from Table 8.44. For wet/dry forming calculated from Table 8.44.

Plants larger than 100 BPD will begin to show the same decline of ROI to low levels and a similar decline in debt coverage ratios.

Table 8.77

COMPARISON OF CONTROL COSTS FOR PRETREATMENT AND NSPS LEAD

ANNUALIZED CONTROL COSTS

(In Thousands of Dollars)

	Wet Forming Manufacturing		Wet/Dry Forming[1] Manufacturing	
	100 BPD	250 BPD	100 BPD	250 BPD
Pretreatment	$18.6	$30.6	$29.7	$48.8
NSPS Lead (Reconstructed/ Modified plants)	32.8	34.9	32.8	34.9

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[1] Based on 80% of production wet, 20% dry.

8.4.4.9 Conclusion

Table 8.78 shows a summary of the economic impacts which were discussed in previous sections. As can be seen, existing wet/dry plants which have to meet sulfuric acid mist control should be able to meet the standard without incurring significant impacts. ROI* does not decrease drastically and their debt coverage remains adequate to obtain financing after control costs are incurred.

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*It should be reiterated here that these ROI figures in Table 8.78 are high for reasons cited in section 8.4.4.3.

Table 8.78

SUMMARY OF ECONOMIC IMPACTS

Plant Description	ROI Before Control	ROI After Control	ROI After Control and Testing	Debt Coverage (After Control)[1]	Debt Coverage After Control and Testing[1]
Sulfuric Acid Mist (Wet/Dry Existing)					
Manufacturing					
100 BPD	26.4%	23.6%	22.7%	2.8	2.5
250 BPD	53.5	48.8	48.1	4.3	4.0
Assembling					
100 BPD	32.3	27.6	26.2	2.2	1.9
250 BPD	62.9	54.6	53.6	4.9	4.3
Sulfuric Acid Mist and NSPS Lead (Wet/Dry Reconstructed)					
Manufacturing					
100 BPD	19.7	7.0	6.0	1.5	1.3
250 BPD	39.0	25.0	24.1	2.7	2.4
Assembling					
100 BPD	25.3	6.4	5.3	1.4	1.2
250 BPD	49.5	27.2	26.3	2.8	2.5
NSPS Lead (Wet Reconstructed)					
Manufacturing					
100 BPD	21.0	9.9	9.2	1.6	1.5
250 BPD	38.6	28.7	28.3	2.8	2.7
Assembling					
100 BPD	27.7	10.5	10.0	1.6	1.5
250 BPD	50.7	34.1	33.7	3.3	3.1

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[1] With partial cost pass through except for sulfuric acid mist control alone where no cost pass through is assumed.

Though ROI declines by 15 percentage points for the 250 BPD wet/dry reconstructed manufacturing plants and 23 percentage points for the assembling plants meeting both sulfuric acid mist control and NSPS lead control, their ROI is still sufficiently high (even if the calculated asset base were doubled) relative to alternative investments for them to remain in the industry. Obtaining financing for control equipment and testing costs should also prove possible based on their debt coverage ratio. The 100 BPD plant is unlikely to be able to finance the required control equipment and may be unwilling to remain in the industry with the depressed ROI which develops after control, even with some cost pass through.

The 250 BPD wet reconstructed plants who have to meet only the NSPS lead control standard are less severely impacted than the wet/dry plants in all respects. In only having to meet NSPS lead standard, their ROI and debt coverage are both adequate and higher than the wet/dry plant. The 100 BPD wet plant would be in a situation after control where he may also consider leaving the industry. With his debt coverage of 1.5 it should not prove possible to obtain conventional financing.

Another financing possibility for the 100 BPD operator is to seek financing through the SBA. Long-term, low interest loans for control equipment, which may include process changes as control methods, will enable him to spread his annual capital cost burden over a longer time span.

In the preceding analysis it was assumed that all affected facilities, namely, casting, pasting and the 3-P operation, would be replaced simultaneously shortly after the promulgation of the standards, and, therefore, would all require NSPS controls at the same time. It is felt that this is very unlikely to happen in reality.

A number of realistic alternatives exist for the small operator even after the promulgation of lead and sulfuric acid mist regulations. The small operator could continue and is likely to utilize his existing process equipment without substantial reconstruction or replacement up to a point in the future when the equipment maintenance costs become prohibitive. At that time his market position is likely to dictate his strategy. Should his business sales be expanding the small plant management could then decide to replace each affected facility over a period of time. This strategy would insure that the incurring of control costs would take place over a period of time and at his own convenience and would mitigate the ROI and cash flow problems shown in previous sections. Should his sales be constant or decreasing he could decide to discontinue battery production entirely and expand the service part of the business, or to become a distributor of larger companies batteries. In certain cases where the plant is in a stronger financial position and where the market is somewhat protected by transportation costs or product specialization, the company may attempt to expand to spread the control costs over a larger sales base.

With each of the alternatives listed above, the economic impact of the NSPS lead standard will be felt gradually over a long period of time instead of immediately after the promulgation of the standard, and all at once, as depicted in the analysis above.

As mentioned in Section 8.4.4.5, the wet/dry plant has the option of discontinuing dry formation to avoid the sulfuric acid mist control. This cost cannot be postponed, however, because it applies to existing plants as well as to new and reconstructed/modified plants. When pretreatment water pollution control costs are also considered, the incentive to discontinue dry production becomes even more pronounced for the small plant.

Thus, the impact of NSPS lead and sulfuric acid mist regulations is to generally favor a status-quo in terms of exisitng plant equipment. New plants are not expected to be built with capacities of 500 BPD or less, and any replacement, reconstruction or modification of an existing plant can be so structured as to minimize a one-time, immediate, significant economic impact projected in the preceding analysis, and to spread it out at the discretion of the plant management.

There is no data on the size distribution of the approximately 91 small plants. Most assemblers, though, would probably be in the 100 BPD area so that minimum estimate of the number of small plants which would be severely impacted is approximately 30.

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9.0 RATIONALE FOR THE PROPOSED STANDARDS

9.1 SELECTION OF SOURCE FOR CONTROL

The largest single use of lead in the United States is in the manufacture of lead-acid, or secondary, storage batteries. There are approximately 190 lead-acid storage battery manufacturing plants in the United States.[1] Projections of growth rate in the lead-acid battery industry range from 3 to 5 percent annually over the next 5 years.

Facilities at lead-acid battery plants emit lead-bearing and non-lead-bearing particulates, and sulfuric-acid mist. Both lead and sulfuric acid mist have been determined to be health related pollutants. Total lead emissions from the industry in 1975 were estimated to be about 82 Mg (90 tons), or about 0.4 percent of the total atmospheric lead emissions from stationary sources in the United States. Most lead-acid battery plants are located near residential areas. Therefore, under the provisions of Section 111(b)(1)(A) of the Clean Air Act, as amended, the Administrator has included the lead-acid battery industry as an air pollution source category which may reasonably be anticipated to endanger public health or welfare.

9.2 SELECTION OF POLLUTANTS AND AFFECTED FACILITIES

9.2.1 Selection of Pollutants

Lead-acid battery plants emit both lead-bearing and nonlead-bearing particulate matter from lead oxide production, grid casting, paste mixing, lead reclamation and assembling facilities. As mentioned earlier, it has been determined that lead is a health related pollutant. Atmospheric dispersion modeling was used to estimate maximum ambient concentrations of lead in the vicinity of lead-acid battery plants. The results of this study are discussed in detail in Section 7.1.1.1. The estimated annual ambient impacts of 500 and 6500 bpd plants controlled only to the extent required by existing State regulations are 4 $\mu g/m^3$ and 8 $\mu g/m^3$, respectively. The National Ambient Air Quality Standard for lead is 1.5 $\mu g/m^3$ on a quarterly basis. For this reason, and because most lead-acid battery plants are located near residential areas, standards are proposed for the lead fraction of the particulate emissions. The reduction of lead emissions to the levels of the proposed standards at affected 500 and 6500 bpd plants would result in the reduction of the average annual ambient impacts of lead emissions from these plants to less than 1 $\mu g/m^3$.

Standards are not proposed for the nonlead fraction of particulate emissions for two reasons. First, such emissions are slight. Second, limitation of the lead emissions will also reduce emissions of other particulates.

In addition to lead-bearing particulate matter, plants using dry formation techniques emit sulfuric acid mist. This mist results from the entrainment of sulfuric acid in hydrogen bubbles which are generated during the formation process. Wet formation takes place in covered battery cases. Therefore, acid mist emissions from wet formation are small. Two literature sources indicate acid mist emission rates from dry formation of 14 Kg (30 lb) and 19 Kg (42 lb) per 1000 batteries.[2,3]

Because sulfuric acid mist has been determined to be a health related pollutant, the Administrator considered proposing standards for the lead-acid battery manufacturing industry which would limit acid mist emissions as well as lead emissions. If the emission rate measured by EPA for dry formation had been as high as the rates presented in the literature, there may have been cause to propose acid mist standards. However, EPA tests on dry formation at one plant indicate that the sulfuric acid mist emission rate from this facility is only about 1.1 Kg per 1000 batteries (see Section 7.1.2). Dispersion modeling studies based the results of EPA emission tests indicate that the maximum ambient impact of sulfuric acid mist emissions from the dry formation process at a plant as large as 6500 batteries per day would be less than 1 $\mu g/m^3$. Therefore, standards for acid mist are not being proposed at this time.

EPA is required to review new source performance standards at least every four years, and, if appropriate, revise them. Thus, new source performance standards for lead-acid battery manufacture may be revised in the future to include standards limiting sulfuric acid mist emissions.

9.2.2 Applicability

The proposed standards of performance would apply to facilities at any lead-acid battery plant that has a production capacity greater than or equal to 500 bpd. Plants with capacities smaller than 500 bpd are exempted from the proposed standards for several reasons. First, projections of the economic impact of standards on existing small plants (100 and 250 bpd) undergoing reconstruction or modification indicated that standards would have a severe negative impact on such plants. Also, although almost 50 percent of the lead-acid battery plants in the United States produce fewer than 500 bpd, these plants account for only about 2 percent of total lead-acid battery production. Finally, industry representatives do not forecast construction or expansion of small plants. In fact there has been a trend in recent years of small plants closing due to unprofitability. Increased demand for batteries in the future is expected to be accommodated by expansion of existing plants producing over 2000 bpd.

9.2.3 Selection of Affected Facilities

Processes selected as affected facilities are grid casting, lead oxide production, paste mixing, three-process operation, lead reclamation, and other lead-emitting operations. These processes often consist of several machines or production lines which perform the same function and which are located in the same area and ducted to the same control device. Therefore, for each of the processes mentioned above, the affected facility is the entire operation.

9.2.2.1 Grid Casting--

The grid casting operation includes grid casting furnaces, which melt the lead, and grid casting machine which cast the liquid metal into grids. Although emissions from the grid casting operations are generally low, most grid casting work areas must be ventilated to comply with the in-plant OSHA lead concentration standard of 50 $\mu g/m^3$. Source tests for the present study detected uncontrolled lead emissions of approximately 0.4 kg (0.9 lb) per 1000 batteries. This is about 3.2 percent of the overall plant uncontrolled lead emissions of 12.6 kg (27.7 lb) per 1000 batteries (including lead reclamation and lead oxide production). Therefore, grid casting is designated an affected facility.

9.2.2.2 Lead Oxide Manufacturing--

The lead monoxide used in battery paste production is called lead oxide, black oxide, or battery oxide. It is produced either by the ball mill or the Barton process. Fabric filters are always used as part of the process for product recovery. Source tests for this study indicate lead emissions of 0.05 kg (0.116 lb) per 1000 batteries from a typical lead oxide facility. Although the lead emissions from a typical lead oxide manufacturing process are low, it is estimated that well-controlled lead oxide manufacturing facilities emit only half as much lead as one designed only for economical recovery of lead oxide. Thus, the lead oxide production process is designated an affected facility.

9.2.2.3 Paste Mixing--

The paste making operation is a batch process that consists of materials charging followed by blending in either a muller, Day, or dough-type mixer. Emissions are in the form of lead oxide with small amounts of other paste constituents such as Dynel, organics, and carbon black. Paste mixing is selected as an affected facility because uncontrolled lead emissions from the process are approximately 5.1 kg (11.2 lb) per 1000 batteries. This is 40 percent of the total estimated lead emissions from a lead-acid battery plant.

9.2.2.4 Three-process Operation--

The three-process operation includes plate stacking, burning, and assembly of elements into the battery case. Emissions consist of lead, lead oxide, and nonlead bearing particulate from the separators. These emissions are generated during plate handling, plate stacking, and burning or casting operations. Source tests indicate that lead emissions from the three-process operation are 6.7 kg (14.7 lb) per 1000 batteries. This is over 50 percent of the estimated emissions of lead from a lead-acid battery plant. Therefore, the three-process operation is designated as an affected facility.

9.2.2.5 Lead Reclamation--

Lead reclamation is an operation wherein relatively clean scrap is remelted and cast into ingots for use in the process. This is often a sporadic operation, on stream only when large quantities of defective small parts, grids, and plates are available. The lead is melted at relatively low temperatures 370° C (700° F), but lead emissions can be high during scrap charging or dross removal. Lead emissions are estimated at 0.35 kg (0.77 lb) per 1000 batteries or 3.0 kg/Mg (5.9 lb/ton) of lead charged. A 4000-bpd plant that operates its lead reclamation facility for an 8-hour shift every 2 weeks would emit approximately 1.7 kg/h (3.8 lb/h) during operation. This amount is comparable to lead emissions from the three-process operation at the same plant. Thus, the lead reclamation operation has been designated as an affected facility. Reverberatory furnaces which are used for lead reclamation but which are affected by standards of performance for secondary lead smelters (40 CFR 60.120) would not be affected under the proposed standards.

9.2.2.6 Other Lead-Emitting Operations--

Any lead-acid battery plant facility from which lead emissions are collected and ducted and not considered part of the grid casting, paste mixing, three-process operation, lead oxide production, or lead reclamation facilities, and which is not a reverberatory furnace affected by standards of performance for secondary lead smelters is considered an "other lead emitting operation". An example is slitting, a process whereby lead grids, cast in doublets, are slit (with an enclosed saw) into separate plates. These types of facilities could be controlled by a separate control device, but are usually ducted to a control device serving other facilities. EPA has selected other lead emitting operations as affected facilities to ensure that these processes are controlled.

9.3 SELECTION OF THE BEST SYSTEM OF EMISSION REDUCTION CONSIDERING COSTS

Emission control alternatives for a lead-acid battery plant are

Table 9-1. SELECTED CONTROL ALTERNATIVES FOR LEAD-ACID BATTERY MANUFACTURING INDUSTRY

Plant size, BPD	Control alternative	Facilities[a]	Control system[b]
500, 2000, & 6500	I	A, B, F	Fabric filter, 6/1 A/C
		C, E	Fabric filter, 6/1 A/C
		D	Fabric filter, 2/1 A/C
	II	B, C, E	Fabric filter, 6/1 A/C
		F	Impingement and entrainment scrubber
		A	Impingement and entrainment scrubber
		D	Fabric filter, 2/1 A/C[c]
	III	C, E	Fabric filter, 6/1 A/C
		A, B, F	Impingement and entrainment scrubber
		D	Fabric filter, 2/1 A/C
	IV	A, B, C	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C
		F	Impingement and entrainment scrubber
		D	Fabric filter, 2/1 A/C[c]
	V	A, B, C, F	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C
		D	Fabric filter, 2/1 A/C[c]
100 & 250[d]	VI	A, B, C	Fabric filter, 6/1 A/C
		E	Fabric filter, 6/1 A/C
	VII	A, B, C, E	Fabric filter, 6/1 A/C
	VIII	A, B, C	Impingement and entrainment scrubber
		E	Fabric filter, 6/1 A/C

[a] Facilities key: A - grid casting furnace; B - grid casting machines; C - paste mixer; D - lead oxide manufacturing; E - three-process operation; F - lead reclamation furnace.

[b] Facilities are vented to common control systems as shown.

[c] Small plants (500 bpd or less) are assumed to have no lead oxide manufacturing facilities.

[d] Plants smaller than 500 BPD are assumed to have no lead reclamation facilities.

Table 9-2. SUMMARY OF ALTERNATIVE CONTROL SYSTEMS COSTS AND CONTROL EFFECTIVENESS FOR LEAD-ACID BATTERY PLANTS (METRIC UNITS)

Control alternative[a]	Plant capacity, bpd	Lead emissions, kg/day		Lead removal, %	New plant control systems cost, $1000[b]		Existing plant control systems cost, $1000	
		Uncontrolled	Controlled		Installed[c]	Annualized[d]	Installed[c]	Annualized[d]
I	500	6.2	0.06	99.0	125	47.4	105	53.6
	2000	25.0	0.30	98.8	211	108	253	118
	6500	81.6	0.99	98.8	453	284	544	305
II	500	6.2	0.09	98.6	151	56.9	181	64.1
	2000	25.0	0.40	98.4	228	122	274	133
	6500	81.6	1.31	98.4	474	303	569	326
III	500	6.2	0.10	98.4	120	47.6	144	53.4
	2000	25.0	0.42	98.3	200	107	240	117
	6500	81.6	1.43	98.3	423	277	508	297
IV	500	6.2	0.33	94.8	110	30.2	132	35.4
	2000	25.0	1.30	98.4	154	48.1	185	55.8
	6500	81.6	4.38	94.6	295	91	354	105
V	500	6.2	0.33	94.8	69	19.4	83	22.7
	2000	25.0	1.30	98.4	119	36.9	143	42.6
	6500	81.6	4.41	94.6	252	78	302	100
VI	100	1.22	0.0122	99.0	89	28.6	107	32.8
	250	3.04	0.0304	99.0	95	30.4	114	34.9
VII	100	1.22	0.0122	99.0	124	44.3	149	50.2
	250	3.04	0.0304	99.0	136	47.0	163	53.5
VIII	100	1.22	0.0615	94.9	94	26.1	113	30.6
	250	3.04	0.154	94.9	100	27.6	120	32.4

[a] A description of each control alternative is presented in Chapter 6. None of there alternatives include acid mist control.

[b] Mid-1976 dollars.

[c] Excludes SIP compliance costs estimated at $35,000, $35,000, $91,000, $95,000, and $105,000 for plants with capacities of 100, 250, 500, 2000, and 6500 bpd, respectively.

[d] Excludes costs of controlling facilities that require controls to meet SIP regulations.

Table 9-2A. SUMMARY OF ALTERNATIVE CONTROL SYSTEMS COSTS AND CONTROL EFFECTIVENESS FOR LEAD-ACID BATTERY PLANTS (ENGLISH UNITS)

Control alternative[a]	Plant capacity, bpd	Lead emissions, lb/day		Lead removal, %	New plant control systems cost, $1000[b]		Existing plant control systems cost, $1000	
		Uncontrolled	Controlled		Installed[c]	Annualized[d]	Installed[c]	Annualized[d]
I	500	13.8	0.138	99.0	125	47.4	105	53.6
	2000	55.3	0.665	98.8	211	108	253	118
	6500	180	2.18	98.8	453	284	544	305
II	500	13.8	0.193	98.6	151	56.9	181	64.1
	2000	55.3	0.885	98.4	228	122	274	133
	6500	180	2.89	98.4	474	303	569	326
III	500	13.8	0.214	98.4	120	47.6	144	53.4
	2000	55.3	0.940	98.3	200	107	240	117
	6500	180	3.15	98.3	423	277	508	297
IV	500	13.8	0.718	94.8	110	30.2	132	35.4
	2000	55.3	2.88	94.8	154	48.1	185	55.8
	6500	180	9.67	94.6	295	91	354	105
V	500	13.8	0.718	94.8	69	19.4	83	22.7
	2000	55.3	2.88	94.8	119	36.9	143	42.6
	6500	180	9.73	94.6	252	78	302	100
VI	100	2.68	0.0268	99.0	89	28.6	107	32.8
	250	6.70	0.0670	99.0	95	30.4	114	34.9
VII	100	2.68	0.0268	99.0	124	44.3	149	50.2
	250	6.70	0.0670	99.0	136	47.0	163	53.5
VIII	100	2.68	0.136	94.9	94	26.1	113	30.6
	250	6.70	0.339	94.9	100	27.6	120	32.4

[a] A description of each control alternative is presented in Chapter 6. None of there alternatives include acid mist control.

[b] Mid-1976 dollars.

[c] Excludes SIP compliance costs estimated at $35,000, $35,000, $91,000, $95,000, and $105,000 for plants with capacities of 100, 250, 500, 2000, and 6500 bpd, respectively.

[d] Excludes costs of controlling facilities that require controls to meet SIP regulations.

discussed in Chapter 6, and the economic impacts of the alternatives are discussed in Chapter 8. Table 9-1 summarizes control alternatives for lead emissions, while Tables 9-2 and 9-2A summarize the costs of the alternatives and their overall lead removal efficiencies. The control alternatives and their economic impacts are discussed in further detail in Chapters 6 and 8.

The impacts of alternatives I through V were analyzed for 500, 2000, and 6500 bpd plants. Alternatives VI through VIII are control alternatives for smaller plants, and take into account the differences between these plants and larger plants. The impacts of these alternatives were analyzed for 100 and 250 bpd plants. For reasons discussed earlier, standards are not being proposed for plants smaller than 500 bpd.

As discussed in Chapter 8, for plants with capacities greater than 500 bpd, the costs of any control alternative are not viewed as being a detriment to industry expansion, nor are they of the magnitude that would impose a negative impact on the debt structure of an individual company. Plants of this size can pass on control costs to the consumer with little effect on sales. The replacement demand for lead batteries will remain high since substitutes have not yet been proven feasible for general use. The original equipment market for lead batteries will not be affected since the battery cost compared to the final product (e.g., automobiles, etc.) is small.

The proposed standards are based on the control of all lead emissions from lead-acid battery plants by fabric filtration (Alternative I). This basis was chosen because fabric filters achieve a better degree of emission reduction than low energy scrubbers at a reasonable cost, and because, the use of fabric filtration to control all lead emissions from lead-acid battery plants is possible if spark arresters are used when necessary and exhaust gases are kept above the dew point.

The use of control techniques other than fabric filtration would not be precluded by the proposed standards. High energy impingement scrubbers could be used to meet the emission limits. However, these would have higher operating costs and energy requirements than fabric filters. Scrubbers would also generate lead contaminated water, which would probably require treatment prior to disposal.

9.4 SELECTION OF THE FORMAT OF THE PROPOSED STANDARD

In general, lead-acid battery manufacturing facilities may be considered independent of one another in that there is no continuous flow of materials. Grid casting operations, lead oxide production operations, paste mixing operations, lead reclamation operations, and three-process operations are independent. Also, not all plants have lead reclamation and lead oxide production operations, and some plants sell lead oxide.

Because of the independent nature of the facilities, two different forms were chosen for the proposed standards. The format of the proposed standards applicable to grid casting, paste mixing, three-process operation, lead reclamation, and other lead-emitting operations, is a concentration standard. The format of the standard for lead oxide manufacturing is mass per unit of lead input.

These forms were chosen for the proposed standards from a group of several possible formats. The standards could, for example, have been expressed in terms of grams of lead emissions per 1000 batteries, or in terms of the lead removal efficiency of the emission control system. The rationale for the choice of the forms of the proposed standards over other possible forms is discussed in detail below.

9.4.1 Multiple Forms

Each affected facility or each process within an affected facility could be subjected to standards having different forms. For example, the standard for paste mixing could be expressed in terms of grams of lead emissions per kilograms of lead oxide charged to the mixer, whereas the standard for the three-process operation could be expressed as grams of lead emissions per 1000 batteries produced. Although this may seem to be the best approach on an individual process basis, the practice of exhausting more than one facility to a common cntrol device complicates the application of different standards to combined gas streams. The difficulties lie in designating the emissions in an acceptable common form and determining an allowable limit for the combined processes or facilities.

A standard that also requires that each affected facility be exhausted to an individual control system would allow various forms to be applied easily to different processes. However, such a standard, by requiring several control systems where one may have sufficed, would increase both the cost of compliance and the cost of compliance testing.

9.4.2 Process Throughput

A standard based on an allowable mass of emissions per mass of process throughput was considered for lead reclamation, three-process operation, grid casting, and paste mixing. However, though lead throughput can usually be determined for each of these processes, emissions depend more on other factors such as the type of scrap processed by a lead reclamation furnace, the number (rather than the weight) of plates processed by a grid casting operation, the method of battery assembly, and the length of the formation cycle. Also, some of these processes typically share control devices with other processes. Therefore, a format of process throughput is not proposed for lead reclamation, the three-process operation, grid casting, paste mixing, and other miscellaneous facilities.

The device controlling emissions from a lead oxide production facility is never shared by other processes. Therefore, a standard based on production throughput could be applied to this process. Also, the amount of lead used by the facility can be readily determined. Concentration units could be applied to the process, but would provide no incentive for the operator to minimize the amount of air which bleeds into the process, which operates under negative pressure. For these reasons, the recommended format of the lead oxide production standard is allowable mass per unit of lead feed (g/kg).

9.4.3 Common Control System

Consideration was given to a standard that would require all facilities to be vented to one control system. This would facilitate compliance testing and would allow placement of all plants on the same unit basis. A standard with this format might also encourage the reduction of handling steps and more efficient production techniques to reduce emissions. If all processes were vented to one system, a single lead standard could apply to each plant regardless of the production techniques.

There are also disadvantages to implementing a standard that requires a single control system. It would limit acceptable plant layout designs to those that minimize ductwork to the control device. Also, plants covered by the modification and reconstruction provisions could not use existing controls. In addition, these plants might find it impractical to install the long ducts needed to vent all facilities to a common device. During compliance tests, a shutdown of one facility would invalidate the test, and more than one process engineer would be required to monitor normal operation at all processes during compliance tests.

It is not recommended that a common control system condition be added to the standard because of possible plant design problems, potential higher cost of a common control system, and the difficulties associated with compliance testing.

9.4.4 Removal Efficiency Standard

An efficiency format would encourage optimum performance of all controls. This type of format, however, would double the sampling effort since both inlet and outlet samples would be required. Also, an increase in lead control efficiency does not necessarily indicate a decrease in atmospheric lead emissions.

9.4.5 Concentration Standard

Concentration units [milligrams per cubic meter (grains per dry standard cubic foot)] are recommended for the standard for grid casting, paste mixing, three-process operation, lead reclamation, and other lead-emitting operations.

Concentration units have the disadvantage of being dependent on the air volume flow rate. In the lead-acid battery industry, the minimim air flow requirement is dictated by the OSHA in-plant regulation of 50 μg lead/m^3 of air based on an 8-hour time-weighted average. Each process must be ventilated sufficiently to meet these standards. No data regarding the optimum ventilation requirements for lead-acid battery manufacturing processes has been uncovered in this study. A maximum air flow rate would be limited by the economics of the greater energy requirements to heat and cool makeup air and the required fan systems. Since the industry is already acutely aware of the high cost of makeup air, it is unlikely that dilution will be used to circumvent a standard that requires the presence of a control device.

On the other hand, gas flow rates are routinely measured as part of the source test procedures; with these flow rate values, emissions in concentration units can be calculated easily. Concentration units will place the standards for the above facilities on a common basis, and thus will eliminate the problems involved in interpretation of the standards for processes vented to a common control device.

With the recommended form of the standard, the major processes common to all battery plants can be assigned a quantitative concentration limit. Lead reclamation and other lead-emitting operations can be vented to a common control device and are also assigned a concentration limit. Standards for the lead oxide production facility, which is not common to all battery plants, and always has its own control system can be based on process throughput.

9.5 SELECTION OF EMISSION LIMITS

Table 9-3 summarizes the recommended emission limits that reflect the degree of emission reduction achievable through the application of the best system of emission reduction based on the Administrator's judgment. The cost of achieving the emission reduction, the nonair-quality health

Table 9-3. RECOMMENDED EMISSION LIMITS FOR LEAD-ACID BATTERY PLANTS

Facility	Pollutant	Recommended Standards*
Grid casting	lead	0.05 mg/m^3 (0.00002 gr/dscf)
Paste mixing	lead	1.00 mg/m^3 (0.00044 gr/dscf)
Three process	lead	1.00 mg/m^3 (0.00044 gr/dscf)
PbO mfg	lead	5.0 mg/Kg (0.010 lb/ton)
Lead reclamation	lead	2.00 mg/m^3 (0.00088 gr/dscf)
Other lead-emitting operations	lead	1.00 mg/m^3 (0.00044 gr/dscf)

*Recommended standards for lead oxide manufacture are in terms of allowed emissions per Kg of lead processed, while those for other facilities are in terms of allowed concentrations in exhaust air.

and environmental impacts, and the energy requirements have been taken into consideration in determining these standards.

The proposed limits for lead emission from grid casting, paste mixing, three-process operation, lead oxide production, lead reclamation, and other lead emitting facilities are based on emissions levels attainable using fabric filtration. In the development of background data for the proposed standards, atmospheric lead emissions from facilities at four lead-acid battery plants were measured using the proposed Method 12. In a previous study, lead emissions from facilities at two lead-acid battery manufacturing plants and one lead oxide manufacturing plant were measured using a similar test method.

The emission limit for three-process operation facilities, lead-oxide production facilities, and other lead emitting facilities are based on lead levels measured in exhausts from fabric filters controlling emissions from such facilities. Fabric filters are not currently used in the lead-acid battery industry to control emissions from grid casting or lead reclamation; and are not generally used to control emissions from the mixing phase of paste mixing. The emission limits for grid casting, paste mixing, and lead reclamation are, therefore, based on lead levels found in uncontrolled emissions from such facilities, and on the demonstrated emission reduction capabilities of fabric filters.

Three-process facilities controlled by fabric filters indicated fabric filter lead collection efficiencies of about 99 percent. Because particulate emissions from all lead emitting facilities at battery plants are simliar in composition and particle size, the Administrator has determined that comparable collection efficiencies can be achieved for emissions from grid casting, paste mixing, and lead reclamation. It should also be noted that control efficiencies of 99 percent and greater are achieved by well maintained fabric filters in other applications.[4,5]

9.5.1 Grid Casting

Impingement scrubbing, rather than fabric filtration, is currently used in the lead-acid battery manufacturing industry to control emissions from grid casting. Emissions from grid casting facilities were measured at two plants. At one of these plants, grid casting emissions were controlled by an impingement scrubber. At the other, grid casting emissions were not controlled. The average lead concentration in exhaust from the uncontrolled facility was 4.37 mg/m^3 (19.1×10^{-4} gr/dscf). Average uncontrolled and controlled lead emissions from the scrubber controlled facility were 2.65 mg/m^3 (11.6×10^{-4} gr/dscf) and 0.32 mg/m^3 (1.4×10^{-4} gr/dscf), respectively. Thus the lead collection efficiency of the scrubber was about 90 percent.

Fabric filtration can be used to control these emissions if spark arresters are used and the exhaust gas is kept above the dew point. Also, because of the low concentration of lead in the exhaust, proper maintenance of the fabric filter would be important. The lead standard for grid casting, 0.05 mg/m^3 (0.2×10^{-4} gr/dscf), is based on the exhaust concentration achievable using a fabric filter with about 99 percent collection efficiency to control emissions.

9.5.2 Paste Mixing

Lead emissions from a paste mixing facility equipped with an impingement scrubber were measured. Average uncontrolled and controlled lead concentrations from this facility were 77.4 mg/m^3 (338×10^{-4} gr/dscf) and 10.8 mg/m^3 (47.0×10^{-4} gr/dscf), respectively.

Fabric filtration is not generally used to control emissions from the entire paste mixing cycle because of the high moisture content of paste mixer exhaust during the mixing cycle. However, fabric filtration can be used to control emissions from the entire cycle if the exhaust gas is kept above the dew point. The proposed lead emission standard for paste mixing, 1 mg/m^3 (4.4×10^{-4} gr/dscf), is based on the level achievable using a fabric filter with about 99 percent collection efficiency for the entire cycle.

In developing data for the proposed standards, EPA conducted tests at a plant where paste mixing emissions were controlled by two separate systems. At this plant, paste mixing required a total of 21 to 24 minutes per batch. During the first 14 to 16 minutes of a cycle (the charging phase), exhaust from the paste mixer was ducted to a fabric filter which also controlled emissions from a grid slitting (separating) operation. During the remainder of the cycle (mixing), paste mixer exhaust was ducted to an impingement scrubber which also controlled emissions from the grid casting operation. Uncontrolled or controlled emissions for the paste alone were not tested. The average concentration of lead in emissions from the fabric filtration system used to control charging emissions was 1.3 mg/m^3 (5.5×10^{-4} gr/dscf). The average lead content of exhaust from the scrubber used to control mixing emissions was 0.25 mg/m^3 (1.1×10^{-4} gr/dscf). The average lead concentration in controlled emissions from this facility was about 0.95 mg/m^3 (4.2×10^{-4} gr/dscf) which is slightly below the proposed emission limit of 1 mg/m^3 (4.4×10^{-4} gr/dscf). A lower average emission concentration should be achieved by using fabric filtration to control emissions from all phases of paste mixing.

9.5.3 Three-Process Operation

The proposed lead concentration limit for three-process operation emissions is 1 mg/m^3 (4.4×10^{-4} gr/dscf). This limit is based on the results of EPA tests conducted at four plants where fabric filtration was used to control three-process operation emissions. All of these tests showed lead concentration below the proposed limit in controlled emissions from the three-process operation facilities.

9.5.4 Lead Reclamation

Lead emissions from a lead reclamation facility where emissions controlled by an impingement scrubber were measured. The average lead concentrations in the inlet and outlet streams of the scrubber were 227 mg/m^3 (990×10^{-4} gr/dscf) and 3.7 mg/m^3 (16×10^{-4} gr/dscf), respectively. The collection efficiency of the scrubber was, therefore, about 98 percent.

Fabric filtration is not currently used to control emissions from lead reclamation facilities because of the high temperature of lead reclamation exhaust. However, fabric filters have been applied to hot exhaust streams at secondary lead smelters and in other industries. Therefore, the proposed standard for lead reclamation facilities of 2 mg/m^3 (8.8×10^{-4} gr/dscf), is based on the emission level attainable using a fabric filter with a collection efficiency of about 99 percent.

9.5.5 Lead Oxide Manufacturing

The proposed standard for lead oxide production is 5 milligrams of lead per kilogram of lead processed (10 lb/ton). This limit is based on the results of tests of emissions from a ball mill lead oxide production facility with a fabric filter emission control system. The tests showed an average controlled lead emission rate of 4.2 mg/Kg (8.4 lb/ton) for this facility. EPA has not conducted tests of emissions from a well controlled Barton process. However, in both the ball mill process and the Barton process, lead oxide product must be removed from an air stream. Also, EPA tests of a Barton process indicated that Barton and ball mill processes have similar air flow rates per unit production rate (see Appendix C). Therefore, it has been determined that a similar level of control could be achieved for a Barton process as has been demonstrated for the ball mill process.

9.5.6 Other Lead Emitting Operations

Emissions from other lead emitting operations are generally collected and ducted to minimize worker exposure. Emissions from these operations are similar in composition and concentration to emissions from non-automated three-process operations. The proposed standard for other lead emitting operations is 1 mg/m^3 (4.4 x 10^{-4} gr/dscf) because emissions from these operations can be controlled to the same extent as emissions from three-process operation facilities.

Emissions were measured from a slitting facility which would be classified as an "other lead emitting operation", controlled by a fabric filter. Controlled emissions from the fabric filter had an average lead content of 0.938 mg/m^3 (4.1 x 10^{-4} gr/dscf), which is below the proposed emission limit for other lead emitting operations.

9.6 OPACITY STANDARDS

A standard of 0 percent opacity is proposed for emissions from all affected facilities in order to ensure proper operation of emission control equipment. Grid casting, paste mixing, three-process operation, and lead oxide manufacturing facilities were observed by EPA to have emissions with 0 percent opacity during periods of 7 hours and 16 minutes; 1 hour and 30 minutes; 3 hours and 51 minutes; and 3 hours and 19 minutes, respectively. Emissions ranging from 5 to 20 percent opacity were observed for a total of 11 minutes and 15 seconds during 3 hours and 22 minutes of observation at the lead reclamation operation source tested by EPA, which was controlled by a low-energy scrubber. However, the proposed standard is based on control of this process by a fabric filter, similar to three-process operations and paste mixers for which emissions with 0 percent opacity have been observed. A standard of 0 percent opacity is, therefore, also proposed for emissions from lead reclamation furnaces.

Under the proposed standards, opacity would be determined by taking the average opacity over a 6-minute period using EPA Test Method 9, and rounding the average to the nearest whole percentage. The rounding procedure is specified in the proposed standards in order to allow occasional brief emissions with opacities greater than 0 percent. When a fabric filter is used to control emissions, the outlet concentration from the filter may increase immediately after a component filter bag is cleaned. In the case of a lead-acid battery plant, filter cleaning may result in occasional emissions with opacities greater than 0 percent. Under Method 9, individual opacity readings are rounded to the nearest 5 percent. However, the average accuracy of any particular opacity reading is ± 7.5 percent opacity. Therefore, the opacity of low level visible emissions during filter cleaning would be interpreted to be 5 percent or greater. If the rounding off procedure were not specified, one opacity reading of 5 percent during a 6-minute period could be considered as indicative of a violation of the proposed 0 percent opacity standard. However, the Administrator does not intend for occasional emissions greater than 0 percent opacity occurring during filter cleaning to be considered violations of the proposed standards. Therefore, the standards would specify that the average opacity be rounded to the nearest whole percentage. With this specification, 6-minute average opacities less than 0.5 percent would not be considered violations of the proposed standards. Emissions which result in 6-minute average opacities of 0.5 percent or greater are expected to be indicative of fabric filter malfunctions rather than filter cleaning emissions.

9.7 MODIFICATIONS/RECONSTRUCTION CONSIDERATIONS

Emission limitations promulgated under Section 111(b) of the Clean Air Act (New Source Performance Standards or NSPS) apply to modified and reconstructed facilities as well as to new facilities. The definitions of modification and reconstruction and the applicability of these provisions to the lead-acid battery industry are discussed in detail in Section 5.1. Basically, with certain exceptions, a modification occurs when a physical or operational change to an existing facility results in an increase in the emission rate to the atmosphere of any pollutant to which an NSPS applies.

Irrespective of any change in pollutant emission rates, a replacement of components of an existing facility may be deemed a reconstruction of that facility if (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a new facility, and (2) it is technologically and economically feasible to meet the applicable standards. One such case could be the replacement of the motor, paddle wheel, and shell of a paste mixer. These repairs would likely exceed 50 percent of the cost of a new paste mixing facility.

The enforcement division of the appropriate EPA regional office should be contacted whenever a source has questions regarding modification or reconstruction. Their judgement will supercede any general examples that can be given in a document such as this.

9.8 SELECTION OF MONITORING REQUIREMENTS

To provide a convenient means for enforcement personnel to ensure that an emission control system installed to comply with standards of performance is properly maintained and operated, monitoring requirements are generally included in standards of performance.

Continuous opacity monitoring is not recommended for lead battery plants because EPA has not determined performance specifications for opacity monitoring for this application. Because even uncontrolled emissions are generally invisible, it is unlikely that available instruments could detect control device malfunction by an opacity change for affected facilities. Also, continuous monitors that directly measure lead concentrations are not commercially available. An indication of proper operation of a scrubber or a fabric filter that can easily be monitored is the pressure drop across the device. This indicator can be continuously monitored with a pressure gauge and strip chart. The installed cost would be less than $2000 with about $400 per year required for operation and maintenance expenses.

Records of the pressure drops for each control device should be kept up to 2 years before discarding. A decrease in pressure drop of about 50 percent could indicate a decrease in lead removal efficiency because of either a fabric filter bag failure or a decrease in scrubber liquid-to-gas ratio. During plant visits, enforcement personnel can examine the pressure charts to determine possible control device malfunctions.

9.9 SELECTION OF PERFORMANCE TEST METHODS

Proposed EPA Reference Method 12, "Determination of Lead Emissions from Stationary Sources;" and EPA Method 9, "Visual Determination of the Opacity of Emissions From Stationary Sources" were selected as the performance test methods to determine compliance with standards of performance limiting lead, and opacity, respectively, from lead battery plants. Methods 1, 2, and 4 are also used for sample and velocity ttraverses, velocity and volumetric flow rate, and stack gas moisture.

Proposed EPA Method 12 is essentialy the same method as was used in gathering the NSPS data, except that it has been revised to include the revisions to Method 5 (Federal Register, August 18, 1977). These revisions were made to make the methods easier to use and to assure that good testing practices were followed. The test results that were obtained before the revisions followed good test practices and will not be affected. Reputable testing firms were used for the lead-battery manufacturing test program; the results obtained are accurate and reliable. Method 12 was developed by the EPA because of the low levels of lead anticipated at the outlet of lead source control devices. This method has greater sensitivity to lead concentrations than atomic absorption analysis of a sample of particulate collected by Method 5.

Method 9 was selected for monitoring opacity. This method was used in the test program and was judged to be applicable to lead battery plants. The method is complete as to methodology, and provides consistent procedures to be applied to all plants tested for compliance with the NSPS.

During all tests, a process engineer should be stationed inside the plant to assure normal operation. When the paste mixer is vented to two control devices, a process engineer must coordinate the process operation with compliance tests. Process downtimes are normally of short duration and should not invalidate the compliance test.

If different processes within a three-process operation facility are controlled by different control devices, source tests must be run on all applicable stacks and an equivalent concentration determined. Total lead emissions from all the stacks can be determined and divided by the total exhaust flow rate. This equivalent concentration can then be compared with the standard.

To determine compliance when two or more facilities at the same plant are ducted to a common control device, the exhaust rate from each source and the controlled lead concentrations must be measured. An equivalent standard for the applicable facilities can be calculated by multiplying each applicable standard by the fractional exhaust flow rate of that facility and adding the numbers. This equivalent standard can then be compared with the measured concentration to determine compliance.

During performance tests on the lead oxide manufacturing the process feed rate must be recorded. This is needed so that lead emission rates for the lead oxide manufacturing process can be expressed in terms of process throughput and compared with the NSPS.

REFERENCES FOR CHAPTER 9

1. Data developed by JACA Consulting, Inc., Philadelphia, Pennsylvania, under EPA Contract No. 68-02-2804 in Support of Lead Ambient Air Standard.

2. Thakker, B. Screening Study to Develop Background Information and Determine the Significance of Emissions from Lead Battery Manufacture. Vulcan-Cincinnati, Inc. Prepared for the U. S. Environmental Protection Agency under Contract No. 68-02-0299, Task No. 3. December 1972. p. 16.

3. Boyle, T. F., and R. B. Reznik. Lead-Acid Batteries, Source Assessment Document No. 17. Prepared by Monsanto Research Corporation, Dayton, Ohio, for the U. S. Environmental Protection Agency. Cincinnati, Ohio. Contract No. 68-02-1874. June 1976 (Draft). p. 42.

4. Compilation of Air Pollutant Emission Factors, Third Edition. U. S. Environmental Protection Agency. AP-42. August 1977.

5. Air Pollution Engineering Manual. U. S. Environmental Protection Agency. AP-40. 1967.

APPENDIX A

EVOLUTION OF THE SELECTION OF THE BEST SYSTEMS OF EMISSION REDUCTION

In development of Standards of Performance for lead-acid battery plants, emissions from selected plants were sampled to help determine the best demonstrated control technology available for new plants. The following steps were involved:

1) Selection of candidate best-controlled plants.
2) Selection of plants to be source tested.
3) Selection of test procedures.
4) Sampling of emissions.
5) Analysis of samples, resolution of data, and development of recommendations.

A chronology of these events is presented in Table A-1.

A.1 SELECTION OF CANDIDATE BEST-CONTROLLED PLANTS

The best controlled lead-acid battery plants were selected by identifying the major emission sources of concern in the industry and then identifying plants that control emissions from these sources effectively. Information was obtained from source test emission data, industry manuals and publications, earlier surveys, and literature on air pollution control and process

Table A-1.

CHRONOLOGY OF EVENTS LEADING TO THE BACKGROUND DOCUMENT FOR NEW SOURCE PERFORMANCE STANDARDS FOR LEAD-ACID BATTERY PLANTS

Date	Event
July 29, 1975	Initial meeting for study regarding Lead Industry New Source Performance Standards at EPA offices in Durham, North Carolina.
August 5, 1975	Meeting with Mr. John Bitler, Chairman of the Air and Water Standards Committee, Battery Council International (BCI) in Reading, Pennsylvania.
August 5, 1975	Visit to General Battery Corporation, Reading, Pennsylvania.
August 28, 1975	Written requests for information regarding lead-acid battery facilities mailed to state air agencies.
August-September, 1975	Written requests for information regarding lead-acid battery facilities mailed to industry representatives.
September 8, 1975	Interim Report No. 1 completed.
September 9, 1975	(Contractor) Project Manager attended Chicago meeting of BCI Air and Water Standards Committee.
October 20, 1975	Visit to Plant G.
October 21, 1975	Visit to Plant B.
October 22, 1975	Visit to Plant D.
October 23, 1975	Visit to Plant F.
November 11, 1975	Visit to Plant E.
November 18, 1975	Visit to Plant C.

Table A-1 (continued).

Date	Event
December 5, 1975	Visit to Plant A.
December 31, 1975	Interim Report No. 2 completed.
February 16, 1976	Meeting for review of Interim Report No. 2 at EPA offices in Durham. Best-controlled plants selected for source testing.
June 14-24, 1976	Source tests conducted at Plant D. Grid casting, paste mixing, and three-process-operations were tested.
August 16-20, 1976	Source tests conducted at Plant B. Three-process-operations and lead oxide production were tested.
August 23-26, 1976	Source tests conducted at Plant G. Formation and lead reclamation processes were tested.
February 8-10, 1977	Visits to formation facilities at ESB, Inc., Allentown, Pennsylvania; and General Battery Co. in City of Industry, California.
April 18-22, 1977	Source tests conducted at the formation process of Plant L.
September 27-28, 1977	National Air Pollution Control Techniques Advisory Committee Meeting (NAPCTAC), Alexandria, Kentucky.
September 27, 1978	EPA Working Group Meeting, Durham, North Carolina.
May 1979	Steering Committee Review

equipment. More than 60 representatives of battery manufacturing companies, trade associations, and air pollution control agencies were contacted through verbal and written communications.

A.1.1 Pollutant Selection

Emissions from lead-acid battery operations are primarily particulate matter containing lead and lead oxide, and sulfuric acid fumes. The available data indicate that emissions from uncontrolled processes could cause ambient levels of lead to exceed 5 μg/m3 (24-hr average) in the vicinity of the larger plants. These levels may cause symptoms of lead poisoning to appear in certain individuals. Emissions of sulfuric acid mist are sensibly detectable at some formation facilities. Plant discharges are generally invisible even when uncontrolled, and particulate emission rates are well below state standards.

Lead was selected as a pollutant for control because of the potential impact of uncontrolled emissions. Because the acid mist emission rate from battery plants was found to be very low, acid mist was not selected for control.

A.1.2 Plant Selection

After selection of the pollutants of concern, the plants that best control these pollutants were identified. Eight plants were selected by consultation with representatives of all the major battery manufacturers, the two battery trade associations, the lead trade association, and state air regulatory agencies. The investigating team visited these plants to determine the facilities to be recommended for source testing. Table A-2 lists the plants and their locations.

TABLE A-2. LEAD-ACID BATTERY PLANTS SELECTED FOR INVESTIGATION

Plant	Location
General Battery Corporation	Reading, Pennsylvania
General Battery Corporation	Los Angeles, California
ESB Incorporated	Buffalo, New York
ESB Incorporated	Allentown, Pennsylvania
ESB Canada Limited	Mississauga, Ontario, Canada
Globe Union	Canby, Oregon
Estee Battery Company	Los Angeles, California
Douglas Battery Manufacturing	Winston-Salem, North Carolina
Delco Battery Manufacturing	Anaheim, California
Standard Electric Company	San Antonio, Texas

A.2 SELECTION OF PLANTS TO BE TESTED

Process and emissions information was obtained during tours of the candidate plants. On the basis of this information, processes from four lead-acid battery plants were recommended for source testing. The recommendations were based on the degree of emissions or process control exercised at the plants and on locations of the source test sites. Relative control efficiencies were evaluated through conversations with plant operators, review of available test data, and visual observations. Table A-3 lists the processes, test locations, and control systems selected for source testing.

TABLE A-3. PROCESSES, TEST LOCATIONS, AND CONTROL SYSTEMS RECOMMENDED FOR SOURCE TESTING

Process	Plant code	Control device	Test locations[a]
Grid casting	D	Roto-Clone	Inlet Outlet
PbO manufacture	B	Baghouse	Outlet
Paste mixing	D	Roto-Clone (mixing cycle) Baghouse (materials charging)	Inlet Outlet Inlet Outlet
Three-process operations	D	Baghouse	Inlet Outlet
	B	Baghouse	Inlet Outlet
Lead reclamation	G	Cascade scrubber	Inlet Outlet
Formation	G	Packed bed mist eliminator	Outlet
	L	Foam + scrubber mist eliminator	Inlet Outlet

[a] Locations relative to control device.

A.3 SELECTION OF TEST PROCEDURES

Standard EPA test methods were available for the pollutants of concern. The EPA Methods provide detailed sampling methodology. Selection of the sampling site and the number of sampling points were well defined. This level of detail was considered necessary for compliance testing to minimize subjectivity and to ensure accuracy, reproducibility, and representativeness.

Unlike in-stack filter methods such as the ASME PTC27 Method and WP-50 Method, EPA specifies all-glass construction except for the probe. A glass probe is required only if the probe length is less than about 8 feet and stack temperatures do not exceed 1320°C (608°F). This will usually be the case in battery plants. Glass equipment is believed superior because it is less reactive.

Therefore, it was decided that the EPA methods would be used for determination of lead and sulfuric acid emissions and of opacities. EPA Methods 5 and 8 were recommended for collection of particulate and sulfuric acid mist emissions, respectively. The lead content of the particulate sample collected by Method 5 was then determined by atomic absorption analysis.

A proposed EPA Method 12 was developed for testing lead emissions at the outlet of the control device because of the low concentrations anticipated at that point. The method was developed to provide greater sensitivity. To confirm the accuracy of the proposed Method 12 for lead-acid battery plant lead emissions, EPA personnel decided to run two sample trains concurrently to determine lead emissions from control device outlets, one train extracting the sample in accordance with EPA Method 5 and the other incorporating a nitric acid impinger train followed by a filter.

The recommended test methods were complete as to both sample extraction and analysis. In addition to the analyses specified in the EPA test methods, particle size classifications were performed by use of impactors, and samples of trace elements were collected. Process data were collected from plant production records and by direct observation.

A.4 DEVELOPMENT OF THE DATA BASE FOR THE STANDARD

Source tests were conducted at the three selected plants during June and August 1976, and April 1977. Results of these tests are summarized in Appendix C. These data, along with values delineating the cost and environmental impacts of several levels of emission control, were presented to the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) in 1977.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

Agency guidelines for preparing regulatory action Environmental Impact Statements (39 Fr 37419; October 21, 1974)	Location within the standards support and Environmental Impact Statement
Background and description of proposed action; Summary of proposed standards.	The proposed standards are summarized in Chapter 1, section 1.1.
Statutory basis for proposed standards.	The statutory basis for the proposed standards is summarized in Chapter 2.
Relationship to other regulatory agency actions.	The various relationships between the proposed standards and other regulatory agency actions are summarized in Chapter 2.
Industry affected by the proposed standards.	A discussion of the industry affected by the standards is presented in Chapter 3, section 3.1. Further details covering the "business/economic" nature of the industry is presented in Chapter 8.
Specific processes affected by the standard.	The specific processes and facilities affected by the proposed standards are summarized in Chapter 1, Section 1.1. A discussion of the rationale for selecting these particular processes or facilities is presented in Chapter 9, Section 9.2.2. A detailed technical discussion of the sources and processes affected by the proposed standards is presented in Chapter 3, Section 3.2 through 3.7.
Alternatives to proposed standard.	A discussion of the alternative emission control systems and their effectiveness is presented in Chapter 6. The costs associated with these systems are presented in Chapter 8, Section 8.2.
Environmental impact.	Estimates of primary and secondary impact of the proposed standards are discussed in Chapter 7.

APPENDIX C

SUMMARY OF TEST DATA

Four lead-acid storage battery plants were tested by EPA to evaluate the best control techniques for controlling lead emissions from grid casting, paste mixing, three-process operation, lead oxide manufacturing, and lead reclamation. Also, a vat-type formation process (dry formation) was tested for emissions of sulfuric acid mist. A brief description of each plant and a summary of the test results are presented in Sections C.1 through C.4.

C.1 PLANT B

Plant B has a normal operating output of 3500 bpd, with a maximum of 4500 bpd.

The major operations are lead oxide production, grid casting, paste mixing, battery assembly (the three-process operation), and formation. Figure C-1 illustrates the general flow of material through Plant B.

The plant manufactures lead oxide by the ball mill process, operating two production lines 5 days per week, 24 hours per day. The normal feed rate for each production line is fifteen 100-pound lead pigs per hour (3000 lb/hr total). The pigs are fed into a Harding rotary mill, which tumbles the pigs to form lead

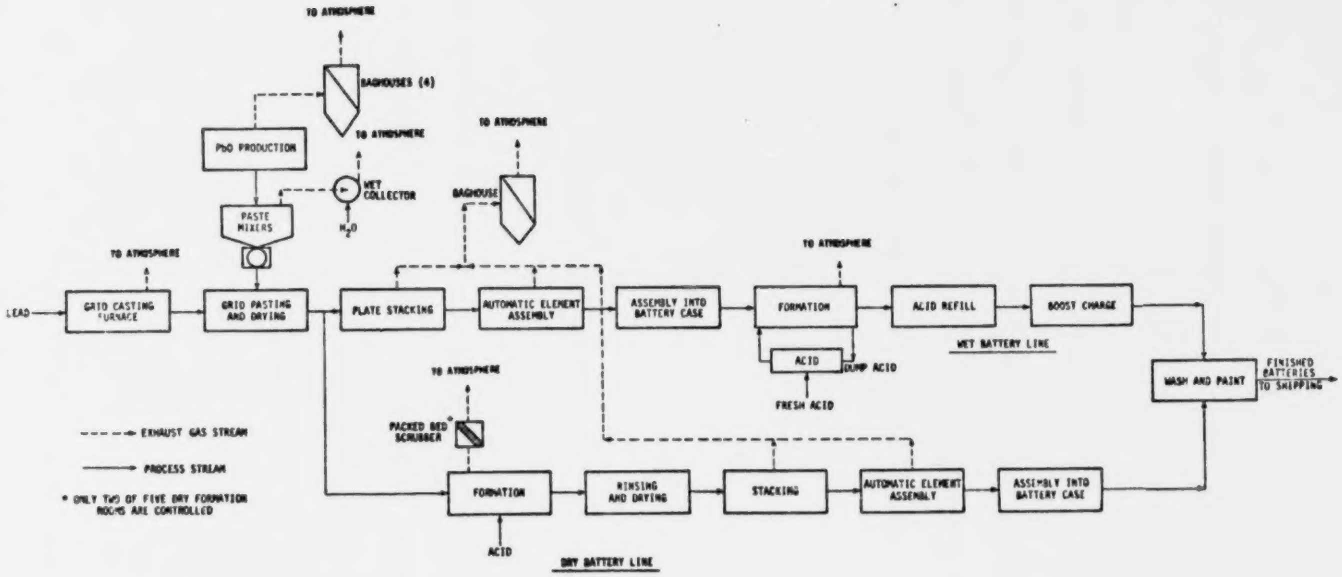
TO ATMOSPHERE
BAGHOUSES (4)
TO ATMOSPHERE
PbO PRODUCTION
WET COLLECTOR
H_2O
PASTE MIXERS
TO ATMOSPHERE
BAGHOUSE
TO ATMOSPHERE
TO ATMOSPHERE
LEAD
GRID CASTING FURNACE
GRID PASTING AND DRYING
PLATE STACKING
AUTOMATIC ELEMENT ASSEMBLY
ASSEMBLY INTO BATTERY CASE
FORMATION
ACID REFILL
BOOST CHARGE
WET BATTERY LINE
ACID
DUMP ACID
FRESH ACID
WASH AND PAINT
FINISHED BATTERIES TO SHIPPING
TO ATMOSPHERE
PACKED BED SCRUBBER*
EXHAUST GAS STREAM
PROCESS STREAM
* ONLY TWO OF FIVE DRY FORMATION ROOMS ARE CONTROLLED
FORMATION
RINSING AND DRYING
STACKING
AUTOMATIC ELEMENT ASSEMBLY
ASSEMBLY INTO BATTERY CASE
ACID
DRY BATTERY LINE

Figure C-1. Production flow diagram, Plant B.

oxide. The material is then screened with a vibrating rotary screen and milled with a Raymond impact mill; the product, collected with a cyclone, consists of approximately 70 percent lead oxide and 30 percent lead. Each lead oxide production line is equipped with two baghouses to provide particulate control and also to collect the product that is not retained by the cyclone separator. Water sprays maintain rotary mill temperatures at about 210°C (410°F).

Production line 1 is controlled by two Mikropul two-compartment baghouses, each having air-to-cloth ratios of 2/1 with both compartments on line. One baghouse controls the screens that follow the rotary mill, and the other controls the product recovery cylone separator and the barrel filling station. The felted dacron bags are cleaned in each compartment every 15 minutes by shaking. During shaking the air-to-cloth ratio is 4/1. These units were rebagged in April 1976.

Lead oxide production line 2 is controlled by two Mikropulsaire baghouses (model no. 64S-6-POTR), each having air-to-cloth ratios of 4/1. One baghouse controls the screens following the rotary mill and the other controls the product recovery cylone separator, a vibrating screen following the cyclone, and the barrel filling station. The felted dacron bags are continuously cleaned by pulse jet.

Exhausts from all four baghouses are combined and released to the atmosphere through a 15-m (50-ft) stack.

The grid casting facility consists of four machines. Each grid cast makes two battery plates after pasting and slitting. The cast grids are taken to the grid pasting machine, where both positive and negative pastes are applied to the grids. After pasting, these double plates are dried, slit in half to make two plates, stacked, and formed.

The paste is produced by mixing dry lead oxide powder, water, and sulfuric acid in two 907-kg/hr (2000-lb/hr) paste mixers. Each mixer is controlled by a separate low-energy impingement-type wet collector designed for a pressure drop of 1992 to 2490 Pa (8-10 in. W.G.) at 56.6 m^3/min (2000 acfm).

The plates used in the dry battery production line are formed in vats of sulfuric acid. After charging, or forming, the plates are rinsed, slit, and stored.

Plates for both wet and dry batteries are processed similarly in the three-process operation. The plates and separators are automatically or manually stacked in the proper sequence. Plant B has four hand stacking stations and two automated stations, (a Reed stacker and a Winkel stacker). Leads (pronounced leeds) and posts are cast on some of these stacks of plates to form elements. Two automatic element assembly units (cast-on-strap machines) are used. The balance of the stacks of plates are processed on a proprietary system, in which the stacks are inserted into specially constructed battery cases and the leads and posts are connected to the plate stacks at a burning station.

The three-process operation is controlled by a Mikro-pulsaire (Model No. 11F 26410) baghouse. Ducts from each process are joined into a 0.76 m (30-inch) duct, and the baghouse exhausts through a 15-m (48-foot) stack that is 0.76 m (30 in.) in diameter. The baghouse is bagged with felted bags and is rated at 566 m^3/min (20,000 acfm) with an air-to-cloth ratio of 6.5/1. The felted bags are continuously cleaned by pulse jet.

Following the three-process operation, batteries from the dry battery line are washed, painted, and sent to shipping; batteries from the wet production line are sent to be formed. These batteries are filled with dilute sulfuric acid and formation is initiated. After the batteries are formed, the acid is replaced with fresh acid. The wet formed batteries are then given a boost charge, washed, painted, and sent to shipping.

At Plant B, source tests were performed on the three-process operation and the lead oxide production facility. The test results are summarized in Tables C-1 and C-1A.
Qualified observers were present during the tests and saw no visible emissions from the stacks being tested.

C.2 PLANT D

Plant D has a normal operating output of 2400 bpd with a maximum of 4000 bpd. The plant is a conventional wet-battery operation, except that the finished units are sent to another plant for formation. Figure C-2 is a schematic diagram of Plant D production flows.

Table C-1. TEST RESULTS SUMMARY FOR PLANT B (METRIC UNITS)

Process	Test No.	Exhaust flow, m^3/min		Exhaust flow, am^3/min		Pb concentration, mg/m^3		Pb emissions, kg/hr		Process through-put	Emission factor g/throughput		Control efficiency %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	
Three-process	1	504	580	530	580	29.9	0.444	0.903	0.016	0.28[a]	3225	56.25	98.3
	2	516	565	547	599	33.6	0.0732	1.043	0.003	0.28[a]	3724	9.07	99.76
	3	516	567	548	604	19.9	0.0435	0.621	0.001	0.28[a]	2218	5.44	99.75
	AVG.	512	571	542	594	27.9	0.188	0.856	0.007	0.28[a]	3056	23.59	99.3
Lead oxide mill	4	N/M	65	N/M	76	N/M	1.13	N/M	0.005	1361[b]	N/M	3.18	N/M
	5	N/M	67	N/M	78	N/M	2.27	N/M	0.010	1361[b]	N/M	6.35	N/M
	6	N/M	67	N/M	78	N/M	1.12	N/M	0.005	1361[b]	N/M	3.18	N/M
	AVG.	N/M	66	N/M	77	N/M	1.51	N/M	0.007	1361[b]	N/M	4.24	N/M

[a] 1000 batteries/hour

[b] kg of lead input/hour

N/M - Not Measured

Table C-1A. TEST RESULTS SUMMARY FOR PLANT B (ENGLISH UNITS)

Process	Test No.	Exhaust flow, dscfm		Exhaust flow, acfm		Pb concentration, gr/dscf		Pb emissions, lb/hr		Process through-put	Emission factor lb/throughput		Control efficiency %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	
Three-process	1	17,800	20,490	18,710	21,340	0.0131	0.000194	1.99	0.0347	0.28[a]	7.11	0.124	98.3
	2	18,210	19,950	19,320	21,150	0.0147	0.000032	2.30	0.0056	0.28[a]	8.21	0.020	99.76
	3	18,210	20,010	19,360	21,340	0.0087	0.000019	1.37	0.0033	0.28[a]	4.89	0.012	99.75
	AVG.	18,070	20,150	19,130	21,280	0.0122	0.000082	1.89	0.0145	0.28[a]	6.74	0.052	99.3
Lead oxide mill	4	N/M	2,310	N/M	2,680	N/M	0.000494	N/M	0.0105	1.5[b]	N/M	0.007	N/M
	5	N/M	2,370	N/M	2,760	N/M	0.000994	N/M	0.0217	1.5[b]	N/M	0.014	N/M
	6	N/M	2,370	N/M	2,750	N/M	0.000489	N/M	0.0106	1.5[b]	N/M	0.007	N/M
	AVG.	N/M	2,350	N/M	2,730	N/M	0.000659	N/M	0.0143	1.5[b]	N/M	0.009	N/M

[a] 1000 batteries/hour

[b] Tons of lead input/hour

N/M - Not Measured

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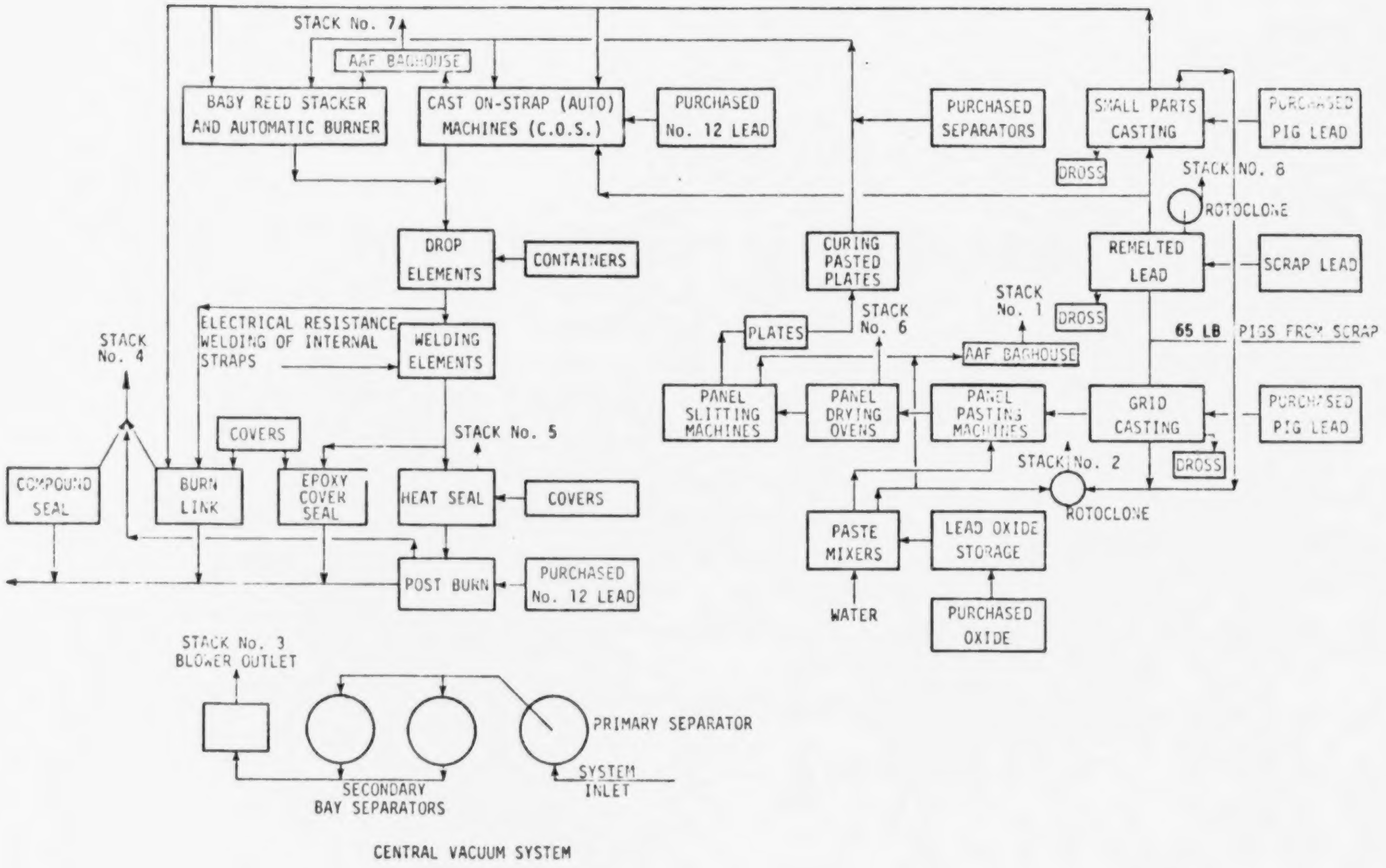
STACK No. 7
AAF BAGHOUSE
BABY REED STACKER AND AUTOMATIC BURNER
CAST ON-STRAP (AUTO) MACHINES (C.O.S.)
PURCHASED No. 12 LEAD
PURCHASED SEPARATORS
SMALL PARTS CASTING
PURCHASED PIG LEAD
DROSS
STACK NO. 8
ROTOCLONE
DROP ELEMENTS
CONTAINERS
CURING PASTED PLATES
REMELTED LEAD
SCRAP LEAD
STACK No. 1
DROSS
ELECTRICAL RESISTANCE WELDING OF INTERNAL STRAPS
WELDING ELEMENTS
PLATES
STACK No. 6
65 LB PIGS FROM SCRAP
AAF BAGHOUSE
STACK No. 4
PANEL SLITTING MACHINES
PANEL DRYING OVENS
PANEL PASTING MACHINES
GRID CASTING
PURCHASED PIG LEAD
COVERS
STACK No. 5
STACK No. 2
DROSS
COMPOUND SEAL
BURN LINK
EPOXY COVER SEAL
HEAT SEAL
COVERS
ROTOCLONE
PASTE MIXERS
LEAD OXIDE STORAGE
POST BURN
PURCHASED No. 12 LEAD
WATER
PURCHASED OXIDE
STACK No. 3 BLOWER OUTLET
PRIMARY SEPARATOR
SECONDARY BAY SEPARATORS
SYSTEM INLET
CENTRAL VACUUM SYSTEM

Figure C-2. Production flow diagram, Plant D.

The plant operates three Wirtz grid-casting furnaces, each with three grid casters (a total of nine casters) vented to a common stack. The exhaust ducting is designed for a fourth furnace. A small-parts casting furnace connects to the main casting exhaust system, which is cleaned by an American Air Filter Type N Roto-Clone system (size 24, Arrangement D). The small parts produced are battery element straps used at the Tiegel burning machine.

Plant D is operating one Beardsley and Piper paste mixer, although two identical mixers were originally installed. The second mixer, transfer conveyor, dryer, and curing station have been removed. The common components, such as the baghouse and lead oxide hopper, were designed as part of the mixer system. Positive batches require 1088 kg (2400 lb) of lead oxide; negative batches require 816 kg (1800 lb) of lead oxide.

The paste mixer exhaust vents to two separate control systems. As the lead oxide is dumped, the gases are vented through an American Air Filter Type 3-96 baghouse, equipped with a 56 kW (75-hp) fan. This baghouse has three compartments, with a total of 636 bags. Total cloth area is 813 m^2 (8755 ft^2), yielding an air-to-cloth ratio of 3.3/1. One compartment is closed for approximately 1 minute each 30 minutes for shaking. The air-to-cloth ratio during shaking increases to 4.9/1. The exhaust gases are rerouted during mixing via an automatic damper to the AAF Type N Roto-Clone, which also cleans the casting operation exhaust gas.

The paste is continuously applied to the grids as they are automatically fed to the pasting machine. The pasted grid is then dried, slit (each grid becomes two plates after pasting and slitting), and stacked. The pasting operation is not vented, but the drying operation is. Slitting and stacking operations are vented to the same baghouse that controls the mixer during the portion of the mixing cycle when dry ingredients are added to the mix. The slitting machine can handle 23,500 plates per hour. A spare slitting machine that is used periodically is also vented to the baghouse. This machine was idle during the tests, and its exhaust system was dampered from the baghouse.

The plates are stacked in the proper sequence and joined on three production lines. Two of these lines are equipped with mechanical stackers and a COS machine that casts the straps onto the elements. The other line uses a mechanical stacker, but the elements are joined by burning on leads with a Tiegel machine, which operates much more slowly than the COS machines. The COS machines produce six-celled batteries exclusively; the Tiegel machine produces industrial batteries with three, four, and six cells. Vents from the assembly area enter a common 0.914-m (36-in.)- diameter manifold, which connects to an AAF Type 3-106 baghouse equipped with a 75 kW (100-hp) fan. Total cloth area is 9757 square feet, yielding an air-to-cloth ratio of 3.3/1. One compartment is closed for approximately 1 minute each 30 minutes for shaking. The air-to-cloth ratio during shaking increases to 4.9/1. The assembly area hoods and ducts were designed to capture particulate emissions.

Tests were performed on the grid casting, paste mixing, and the three-process operation at Plant D. The results are summarized in Tables C-2 and C-2A. Qualified observers were present during the tests and saw no visible emissions from the stacks being tested.

C.3 PLANT G

Plant G has a capacity of 1800 bpd and a normal operating output of 1500 bpd. The major facilities include grid casting, paste mixing, the three-process operation, and formation. There is also a small parts casting unit and a lead reclaim pot. Both wet and dry batteries are produced. Figure C-3 is a schematic diagram of Plant G production flow.

Grids are cast on six grid casting machines, which receive lead from two melting pots. This process is not controlled.

One paste mixer is used for both positive and negative pastes. The mixer emissions are controlled by a Schneible, type F61BL, low-energy cascade type, 116-m^3/min (4100-acfm) wet scrubber with a pressure drop of about 1743 to 1992 Pa (7 to 8 in. W.G.).

Finished grids are pasted, dried, and stored. The plate drying ovens are vented to the atmosphere by natural draft. The dried plates can be sent to formation if they are to be used in making dry batteries or to the three-process operation for use in wet batteries.

Table C-2. TEST RESULTS SUMMARY FOR PLANT D (METRIC UNITS)

Process	Test No.	Exhaust flow, m^3/min		Exhaust flow, am^3/min		Pb concentration, mg/m^3		Pb emissions, kg/hr		Emission factor, g Pb/1000 batteries		Control efficiency %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
Three-process Operation	1	964	803	981	809	40.0	0.664	2.309	0.032	9661	134.5	98.6
	2	893	698	918	700	53.5	1.01	2.862	0.042	11935	176.1	98.5
	3[a]	897	805	920	808	2.44	0.664	0.132	0.032	549	134.5	75.5
	AVG.	918	769	940	772	31.9	0.778	1.768	0.035	4481	148.4	90.9
Grid casting (Roto-Clone controlled)	6[b]	414	N/M	502	N/M	0.89	N/M	0.022	N/M	92	N/M	N/M
	7[b]	399	N/M	480	N/M	1.01	N/M	0.024	N/M	100	N/M	N/M
	12[c]	437	473	515	496	5.86	0.320	0.154	0.009	644	37.9	94.1
	13[b]	438	N/M	499	N/M	2.81	N/M	0.077	N/M	308	N/M	N/M
	AVG.	422	473	499	496	2.65	0.320	0.069	0.009	286	37.9	94.1
Grid casting and full mixing cycle (Roto-Clone controlled)	4	435	469	499	498	25.5	0.275	0.696	0.008	2784	32.2	98.8
	7[b]	N/M	462	N/M	512	N/M	0.252	N/M	0.007	N/M	28.4	N/M
	13[b]	N/M	487	N/M	525	N/M	0.206	N/M	0.006	N/M	24.6	N/M
	15	477	526	548	562	2.43	0.229	0.072	0.008	289	30.3	89.5
	AVG.	456	506	524	524	14.0	0.229	0.384	0.007	1536	28.9	94.2
Grid casting and mixing (Roto-Clone controlled)	5	435	452	498	490	1.60	0.160	0.044	0.005	174	18.0	89.6
	6[b]	N/M	459	N/M	504	N/M	0.252	N/M	0.007	N/M	28.4	N/M
	14	482	485	548	505	3.18	0.320	0.096	0.010	384	25.6	89.7
	AVG.	458	465	523	500	2.38	0.252	0.070	0.007	279	24.0	89.6
Slitting (Baghouse controlled)	10	681	685	733	693	43.1	0.938	1.838	0.028	7340	113.7	98.5
Slitting and full mixing cycle (Baghouse controlled)	9	649	702	699	712	66.6	1.17	2.709	0.051	10845	204.6	98.1
Slitting and mixer charging (Baghouse controlled)	8	681	685	726	689	115	1.17	4.925	0.050	19700	200.8	99.0
	11	671	697	708	691	33.7	1.35	1.416	0.059	5680	234.9	96.0
	AVG.	676	691	717	690	74.6	1.26	3.170	0.054	12690	217.8	97.5

[a] Several equipment downtimes during test.

[b] Inlet tested prior to merger of grid casting and mixing exhaust.

[c] Filter broke. Catch was still collected.

N/M - Not Measured

Table C-2A. TEST RESULTS SUMMARY FOR PLANT D (ENGLISH UNITS)

Process	Test No.	Exhaust flow, dscfm		Exhaust flow, acfm		Pb concentration, gr/dscf		Pb emissions, lb/hr		Emission factor lb Pb/1000 batteries		Control efficiency %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
Three-process Operation	1	34,026	28,366	34,660	28,572	0.01746	0.00029	5.09	0.071	20.4	0.284	98.6
	2	31,525	24,641	32,423	24,712	0.02334	0.00044	6.31	0.093	25.2	0.372	98.5
	3[a]	31,674	23,413	32,500	28,523	0.00106	0.00029	0.29	0.071	1.16	0.284	75.5
	AVG.	32,408	27,140	33,194	27,269	0.01395	0.00034	3.90	0.078	15.6	0.313	90.9
Grid Casting (Roto-Clone controlled)	6[b]	14,609	N/M	17,724	N/M	0.00039	N/M	0.0488	N/M	0.195	N/M	N/M
	7[b]	14,095	N/M	16,934	N/M	0.00044	N/M	0.0532	N/M	0.213	N/M	N/M
	12[c]	15,432	16,718	18,199	17,521	0.00256	0.00014	0.339	0.020	1.36	0.08	94.1
	13[b]	15,484	N/M	17,627	N/M	0.00123	N/M	0.163	N/M	0.652	N/M	N/M
	AVG.	14,905	16,718	17,621	17,521	0.00116	0.00014	0.151	0.020	0.605	0.08	94.1
Grid Casting and full mixing cycle (Roto-Clone controlled)	4	15,359	16,569	17,651	17,594	0.01114	0.00012	1.47	0.017	5.88	0.068	98.8
	7[b]	N/M	16,313	N/M	18,073	N/M	0.00011	N/M	0.015	N/M	0.060	N/M
	13[b]	N/M	17,208	N/M	18,548	N/M	0.00009	N/M	0.013	N/M	0.052	N/M
	15	16,852	18,559	19,358	19,849	0.00106	0.00010	0.153	0.016	0.612	0.064	89.5
	AVG.	16,105	17,162	18,494	18,516	0.00610	0.00010	0.811	0.015	3.24	0.061	94.2
Grid Casting and mixing (Roto-Clone controlled)	5	15,347	15,949	17,599	17,312	0.00070	0.00007	0.0921	0.0096	0.368	0.038	89.6
	6[b]	N/M	16,219	N/M	17,787	N/M	0.00011	N/M	0.015	N/M	0.060	N/M
	14	17,032	17,130	19,353	17,842	0.00139	0.00014	0.203	0.021	0.812	0.084	89.7
	AVG.	16,190	16,433	18,476	17,647	0.00104	0.00011	0.1476	0.015	0.590	0.061	89.7
Slitting (Baghouse controlled)	10	24,038	24,179	25,882	24,485	0.01884	0.00041	3.88	0.060	15.5	0.24	98.5
Slitting and full mixing cycle (Baghouse controlled)	9	22,935	24,806	24,679	25,142	0.02909	0.00051	5.72	0.108	22.9	0.432	98.1
Slitting and mixer charging (Baghouse controlled)	8	24,064	24,180	25,636	24,346	0.05046	0.00051	10.4	0.106	41.6	0.424	99.0
	11	23,701	24,614	24,996	24,391	0.01471	0.00059	2.99	0.124	12.0	0.496	96.0
	AVG.	23,882	24,397	25,316	24,368	0.03258	0.00055	6.70	0.115	26.8	0.459	97.5

[a] Several equipment downtimes during test.

[b] Inlet tested prior to merger of grid casting and mixing exhaust.

[c] Filter broke. Catch was still collected.

N/M - Not Measured.

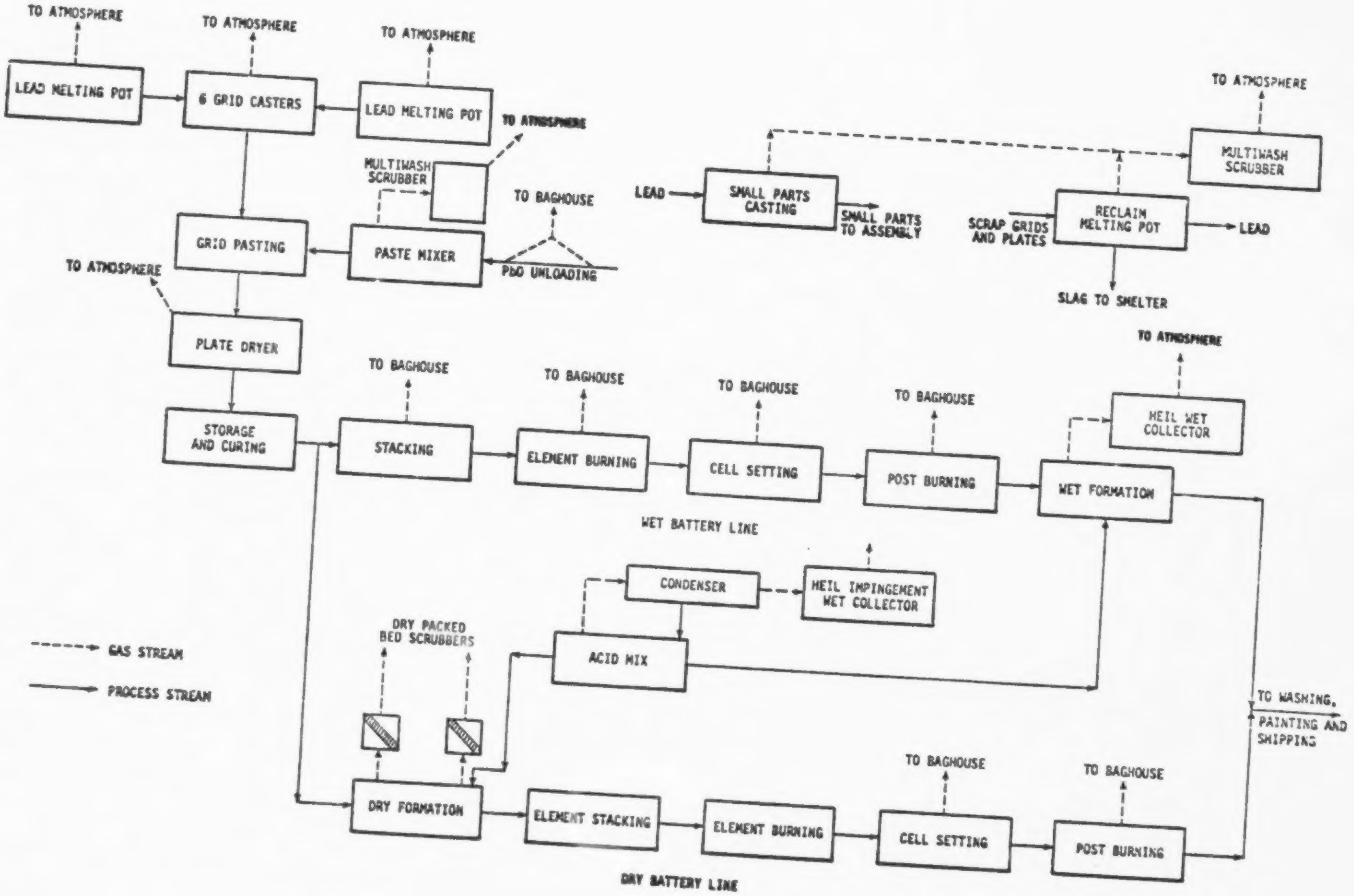
TO ATMOSPHERE
TO ATMOSPHERE
TO ATMOSPHERE
LEAD MELTING POT
6 GRID CASTERS
LEAD MELTING POT
TO ATMOSPHERE
MULTIWASH SCRUBBER
TO BAGHOUSE
GRID PASTING
PASTE MIXER
PbO UNLOADING
TO ATMOSPHERE
PLATE DRYER
STORAGE AND CURING
LEAD
SMALL PARTS CASTING
SMALL PARTS TO ASSEMBLY
TO ATMOSPHERE
MULTIWASH SCRUBBER
SCRAP GRIDS AND PLATES
RECLAIM MELTING POT
LEAD
SLAG TO SMELTER
TO ATMOSPHERE
TO BAGHOUSE
TO BAGHOUSE
TO BAGHOUSE
TO BAGHOUSE
STACKING
ELEMENT BURNING
CELL SETTING
POST BURNING
WET FORMATION
HEIL WET COLLECTOR
WET BATTERY LINE
CONDENSER
HEIL IMPINGEMENT WET COLLECTOR
ACID MIX
DRY PACKED BED SCRUBBERS
GAS STREAM
PROCESS STREAM
TO WASHING, PAINTING AND SHIPPING
TO BAGHOUSE
TO BAGHOUSE
DRY FORMATION
ELEMENT STACKING
ELEMENT BURNING
CELL SETTING
POST BURNING
DRY BATTERY LINE

Figure C-3. Production flow diagram, Plant G.

The dry formation process is totally enclosed and is vented through two Tri-Mer mist eliminators installed in parallel. These units, designed to operate with a water spray, are operated in a dry mode. The packed beds are manually flushed after each cycle with a water and detergent solution. Sulfuric acid mist is collected and recycled. Part of the cleaned air from each scrubber is returned to the formation room for ventilation and the remainder is exhausted to the atmosphere through two stacks. After formation, the elements are dried, rinsed, and sent to the three-process operation.

The three-process operation for both dry and wet battery manufacture consists of stacking the plates, element burning to connect the plates, cell setting (inserting the assemblies into a battery case) and post burning. Emissions from the stacking operation and lead oxide production are vented in a common duct to a 212-m^3/min (7500-acfm) Mikro-Pulsaire, type 8FTV fabric filter. Cell setting and plate welding emissions are vented in a common duct to an identical fabric filter. Exhausts from both baghouses are ducted in turn to a common stack. A 30 kW (40-hp) fan provides suction for both baghouses.

After the three-process operation, the dry batteries are washed, painted, and shipped; the wet batteries are sent to formation. Acid mist from the wet forming room is vented through a Heil water spray scrubber. Wet batteries are washed, painted, and shipped following the formation process.

Deformed grids, posts, connectors, and some scrap plates are remelted in a reclamation furnace and formed into lead pigs to be reused. Most scrap plates and elements along with reclamation furnace slag are sent to a lead smelter for recovery. The reclamation furnace and the small-parts casting facility are vented in a common duct to a Schneible Model No. F-41 multiwash scrubber operating with a water-to-gas ratio of 15.2 to 19.0 liters per 28.3 m^3 (4 to 5 gallons per 1000 acf). The pressure drop is typically 498 to 747 Pa (2 to 3 in. W.G.) with a rated exhaust rate of 99 to 119 m^3/min (3500 to 4200 acfm).

Source tests were performed on the lead reclamation and formation processes at Plant G. Results of the reclamation facility tests are summarized in Tables C-3 and C-3A. Qualified observers were present during the tests and saw no visible emissions from the stacks that were tested.

C.4 PLANT L

Plant L produces about 6000 lead-acid storage batteries per day, using four vat-type formation rooms for manufacturing dry-charged batteries. The plant also manufactures wet-charged batteries. The formation room tested houses two formation circuits, and forms about 20,000 battery plates per day.

The formation process begins with the insertion of pasted battery plates into individual slots in formation tanks, which are about 18 inches wide and 3 feet long. After the plates are loaded into the tanks, the positive plates are connected in a

Table C-3. TEST RESULTS SUMMARY FOR PLANT G (METRIC UNITS)

Process	Test No.	Exhaust flow, m^3/min		Exhaust flow, am^3/min		Pb concentration, mg/m^3		Pb emissions, kg/hr		Scrap input, kg/hr	Emission factor g/kg feed		Control efficiency, %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	
Lead reclamation (Cascade scrubber controlled)	1	92	100	101	107	293	2.14	0.95	0.013	430.9	2.12	0.032	98.6
	2	94	102	107	111	175	4.39	1.21	0.027	403.7	2.92	0.071	97.8
	3	96	100	108	109	214	3.80	1.57	0.023	508.0	3.20	0.048	98.6
	AVG.	94	101	105	109	229	3.44	1.26	0.021	447.5	2.75	0.050	98.3

Table C-3A. TEST RESULTS SUMMARY FOR PLANT G (ENGLISH UNITS)

Process	Test No.	Exhaust flow, dscfm		Exhaust flow, acfm		Pb concentration, gr/dscf		Pb emissions, lb/hr		Scrap input, tons/hr	Emission factor lb/ton feed		Control efficiency %
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet		Inlet	Outlet	
Lead reclamation (Cascade scrubber controlled)	1	3255	3464	3540	3775	0.0765	0.000936	2.10	0.0283	0.475	4.72	0.064	98.6
	2	3341	3594	3756	3915	0.0937	0.00192	2.69	0.0591	0.445	6.45	0.142	97.8
	3	3407	3520	3804	3800	0.128	0.00166	3.72	0.0503	0.560	7.09	0.096	98.6
	AVG.	3334	3526	3700	3830	0.0994	0.00150	2.84	0.0459	0.493	6.09	0.101	98.3

positive source of direct current (DC) and the negative plates are connected to a negative DC source. The tanks are then filled with sulfuric acid which has a specific gravity of about 1.04. After the acid has been added, a foaming agent called Alkanol is added to each tank, and the current is switched on. During the formation process, the lead oxide paste on the positive plates is oxidized to lead peroxide and the lead oxide paste on the negative plates is reduced to metallic lead.

The current is applied to the plates for about 18 hours, which encompasses the entire second and third (evening and night) shifts. The formed plates are removed and unformed plates loaded during the first (day) shift.

Sulfuric acid mist emissions from the process are controlled in two ways. First, emissions from the acid bath contact the foam layer at the surface of the bath and are partially absorbed by the foam layer. The second control mechanism is collection of the unabsorbed mist particles in a Heil Model 704 scrubber which has a water-to-gas ratio of 0.035 to 0.07 liters per cubic meter (1-2 gal./1000 acf) and a pressure drop of 498 to 747 pascal (23 inches of water-gage).

Emissions from parts of four formation cycles were sampled. Only one cycle (Cycle No. 3) was sampled throughout the entire cycle. All emission tests except those on Cycle No. 3 were performed when emissions from the process were controlled using a combination of foam and scrubbing. Emission results from tests on Cycle No. 3 show emissions when the process is controlled by scrubbing only. Additional information on these tests is presented in Tables C4 and C4A.

C.5 OTHER TEST DATA

Other test data used in this study are summarized in Tables C5 and C5A. The data were obtained from tests performed at Plants B, J, and K prior to this study. Both Plants B and J manufacture lead acid batteries while Plant K produces lead oxide.

Table C-4. TEST RESULTS SUMMARY FOR PLANT L (METRIC UNITS)

Plant	Process	Formation Cycle No.	Test No.	Approximate Number of Hours into the Formation Cycle[a]		Exhaust Flow m^3/min		Actual Exhaust Flow am^3/min		H_2SO_4 Mist Concentration mg/m^3		H_2SO_4 Mist Emissions, kg/hr		Control Efficiency, %[b]
				Start	End	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
L	Formation	1	1[c]	6.5	10.5	81.59	107.37	87.56	113.6	6.56	0.57	0.032	0.0046	89
L	Formation	1	2	11.0	16.0	78.53	92.51	84.79	96.73	55.21	0.87	0.259	0.0050	98
L	Formation	2	3	8.0	10.0	83.15	87.14	91.98	93.11	53.34	0.30	0.263	0.0014	99
L	Formation	2	4	12.0	14.0	78.79	91.72	87.11	96.47	76.17	2.20	0.358	0.0122	97
L	Formation	2	5	15.0	16.0	84.02	94.47	93.19	99.64	109.49	5.23	0.549	0.0295	95
L	Formation	3	6	0.0	3.0	85.04	95.94	92.63	101.46	21.82	0.63	0.109	0.0036	97
L	Formation	3	7	3.0	8.5	77.78	101.74	84.90	107.54	33.55	0.60	0.159	0.0036	98
L	Formation	3	8	8.0	9.5	78.53	N/M	85.81	N/M	54.64	N/M	0.254	N/M	N/M
L	Formation	3	9	9.5	13.0	80.29	92.99	87.87	98.14	86.96	1.37	0.417	0.0077	98
L	Formation	3	10	13.0	16.0	76.33	89.37	83.68	94.58	65.21	1.60	0.299	0.0086	97
L	Formation	4	11	12.5	16.0	77.66	82.21	86.80	88.13	24.42	0.90	0.113	0.0045	96

[a] This was a 16 hour formation cycle. The numbers in these columns represent the approximate length of time the process was sampled, and the phase of the formation cycle that was sampled (e.g., Test No. 2 was performed during the last five hours of the first cycle sampled).

[b] Since inlet and outlet samples were not collected simultaneously, these efficiencies are estimates.

[c] Results invalidated by sample equipment failure.

N/M - Not Measured

Table C-4A. TEST RESULTS SUMMARY FOR PLANT L (ENGLISH UNITS)

Plant	Process	Formation Cycle No.	Test No.	Approximate Number of Hours into the Formation Cycle[a]		Exhaust Flow Rate, dscfm		Actual Flow Rate, scfm		H_2SO_4 Mist Emissions, 10^{-4} gr/dscf		H_2SO_4 Mist Emissions, lb/hr		Control Efficiency, %[b]
				Start	End	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
L	Formation	1	1[c]	6.5	10.5	2883	3794	3094	4014	28.67	2.49	0.07	0.008	89
L	Formation	1	2	11.0	16.0	2775	3269	2996	3418	241.29	3.80	0.57	0.011	98
L	Formation	2	3	8.0	10.0	2938	3079	3250	3290	233.99	1.31	0.58	0.003	99
L	Formation	2	4	12.0	14.0	2784	3241	3078	3409	333.07	9.67	0.79	0.027	97
L	Formation	2	5	15.0	16.0	2969	3338	3293	3521	478.52	22.86	1.21	0.065	95
L	Formation	3	6	0.0	3.0	3005	3390	3273	3585	95.36	2.75	0.24	0.008	97
L	Formation	3	7	3.0	8.5	2748	3595	3003	3800	146.64	2.62	0.35	0.008	98
L	Formation	3	8	8.0	9.5	2775	N/M	3032	N/M	238.80	N/M	0.56	N/M	N/M
L	Formation	3	9	9.5	13.0	2837	3286	3105	3468	380.05	5.99	0.92	0.017	98
L	Formation	3	10	13.0	16.0	2697	3158	2957	3342	285.00	6.99	0.66	0.019	97
L	Formation	4	11	12.5	16.0	2744	2905	3067	3114	106.73	3.93	0.25	0.010	96

[a] This was a 16 hour formation cycle. The numbers in these columns represent the approximate length of time the process was sampled, and the phase of the formation cycle that was sampled (e.g., Test No. 2 was performed during the last five hours of the first cycle sampled).

[b] Since inlet and outlet samples were not collected simultaneously, these efficiencies are estimates.

[c] Results invalidated by sample equipment failure.

N/M - Not Measured

Table C-5. TEST RESULTS SUMMARY FOR PLANTS B, J, AND K (METRIC UNITS)

Plant	Process	Control Device	Test No.	Process throughput, Mg/hr	Exhaust Flow Rate, m^3/min		Actual Exhaust Flow Rate, am^3/min		Pb Concentration, mg/m^3		Pb Emissions, kg/hr		Control efficiency %
					Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
B	PbO Mill (Ball Mill)	Product recovery fabric filter	1	1.4	N/M	72.32	N/M	87.16	N/M	0.45	N/M	0.0020	N/M
			2	1.4	N/M	80.50	N/M	93.98	N/M	0.30	N/M	0.0015	N/M
			3	1.4	N/M	77.11	N/M	92.68	N/M	0.43	N/M	0.0020	N/M
			AVG.	1.4	N/M	76.63	N/M	91.27	N/M	0.40	N/M	0.0018	N/M
B	Three-process	Fabric Filter	1	N/M	N/M	526.95	N/M	555.18	N/M	0.05	N/M	0.0015	N/M
			2	N/M	N/M	445.71	N/M	470.71	N/M	0.27	N/M	0.0073	N/M
			3	N/M	N/M	438.97	N/M	473.09	N/M	0.14	N/M	0.0037	N/M
			AVG.	N/M	N/M	470.54	N/M	499.65	N/M	0.15	N/M	0.0042	N/M
J	Grid Casting	Uncon-trolled	1	N/M	N/M	11.9	N/M	15.7	N/M	3.41	N/M	0.0025	N/M
			2	N/M	N/M	11.6	N/M	15.5	N/M	7.05	N/M	0.0049	N/M
			3	N/M	N/M	10.5	N/M	14.1	N/M	2.70	N/M	0.0017	N/M
			AVG.	N/M	N/M	11.3	N/M	15.1	N/M	4.39	N/M	0.0030	N/M
J	Paste mixer	Schneible Scrubber	1	N/M	26.5	27.6	28.71	29.59	63.2	10.5	0.100	0.0187	81.4
			2	N/M	26.8	23.7	29.82	25.85	84.0	10.0	0.135	0.0155	88.5
			3	N/M	25.5	25.9	28.74	28.32	84.9	11.7	0.130	0.0199	85.2
			AVG.	N/M	26.3	25.7	29.08	27.92	77.4	10.8	0.122	0.0181	85.0
J	Three-process	Fabric Filter	1	N/M	321.34	355.23	325.05	374.63	5.95	0.17	0.115	0.0035	96.9
			2	N/M	331.42	352.66	347.19	368.86	2.63	0.07	0.053	0.0015	97.2
			3	N/M	321.85	360.16	334.39	375.00	4.28	0.15	0.083	0.0033	96.0
			AVG.	N/M	324.88	356.02	335.55	372.82	4.28	0.13	0.083	0.0028	96.7
K	PbO Mill (Barton Pot)	Product recovery fabric filter	1	0.70	N/M	35.4	N/M	47.0	N/M	54.2	N/M	0.115	N/M
			2	0.68	N/M	32.8	N/M	44.4	N/M	57.2	N/M	0.113	N/M
			3	0.60	N/M	35.4	N/M	48.4	N/M	104.4	N/M	0.223	N/M
			AVG.	0.66	N/M	34.5	N/M	46.6	N/M	71.9	N/M	0.150	N/M

N/M - Not Measured

Table C-5A. TEST RESULTS SUMMARY FOR PLANTS B, J, AND K (ENGLISH UNITS)

Plant	Process	Control Device	Test No.	Process throughput, ton/hr	Exhaust Flow Rate, dscfm		Actual Exhaust Flow Rate, acfm		Pb Concentration, 10^{-4}gr/dscf		Pb Emissions, lb/hr		Control efficiency %
					Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	
B	PbO Mill (Ball Mill)	Product recovery fabric filter	1	1.5	N/M	2554	N/M	3078	N/M	1.97	N/M	0.0043	N/M
			2	1.5	N/M	2843	N/M	3319	N/M	1.33	N/M	0.0032	N/M
			3	1.5	N/M	2723	N/M	3273	N/M	1.88	N/M	0.0044	N/M
			AVG.	1.5	N/M	2706	N/M	3223	N/M	1.73	N/M	0.0040	N/M
B	Three-process	Fabric Filter	1	N/M	N/M	18609	N/M	19606	N/M	0.215	N/M	0.0034	N/M
			2	N/M	N/M	15740	N/M	16623	N/M	1.19	N/M	0.0161	N/M
			3	N/M	N/M	15502	N/M	16707	N/M	0.609	N/M	0.0081	N/M
			AVG.	N/M	N/M	16617	N/M	17645	N/M	0.671	N/M	0.0092	N/M
J	Grid casting	Uncon-trolled	1	N/M	N/M	420	N/M	555	N/M	14.9	N/M	0.0054	N/M
			2	N/M	N/M	410	N/M	548	N/M	30.8	N/M	0.0108	N/M
			3	N/M	N/M	370	N/M	497	N/M	11.8	N/M	0.0037	N/M
			AVG.	N/M	N/M	400	N/M	533	N/M	19.2	N/M	0.0066	N/M
J	Paste mixer	Schneible Scrubber	1	N/M	936	974	1014	1045	276	46.0	0.221	0.0412	81.4
			2	N/M	945	837	1053	913	367	43.7	0.297	0.0342	88.5
			3	N/M	901	916	1015	1000	371	51.3	0.286	0.0439	85.2
			AVG.	N/M	927	909	1027	986	338	47.0	0.268	0.0398	85.0
J	Three-process	Fabric Filter	1	N/M	11348	12545	11479	13230	26.0	0.73	0.253	0.0078	96.9
			2	N/M	11704	12454	12261	13026	11.5	0.30	0.116	0.0032	97.2
			3	N/M	11366	12719	11809	13243	18.7	0.66	0.182	0.0072	96.0
			AVG.	N/M	11473	12573	11850	13166	18.7	0.56	0.184	0.0061	96.7
K	PbO Mill (Barton Pot)	Product recovery fabric filter	1	0.77	N/M	1250	N/M	1660	N/M	237	N/M	0.253	N/M
			2	0.75	N/M	1160	N/M	1570	N/M	250	N/M	0.249	N/M
			3	0.66	N/M	1250	N/M	1710	N/M	456	N/M	0.491	N/M
			AVG.	0.73	N/M	1220	N/M	1650	N/M	314	N/M	0.331	N/M

N/M - Not Measured

APPENDIX D

EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

As part of the work done under EPA Contract No. 68021219, Arthur D. Little, Inc. performed a review of the recent literature pertaining to lead sampling and analysis. Their recommendation was to employ a Modified EPA Method 5 sampling train for sample collection, with lead analysis to be performed by atomic absorption spectrometry (AAS). Based on this advice, EPA combined these techniques in a working draft, "Determination of Lead Emissions from the Manufacturing of Lead Batteries".

The new source performance standards were based on the results of lead sampling conducted with this method by EPA on grid casting furnaces, paste mixing operations, three process operation, lead oxide production, and lead reclamation.

In this adaptation of the Method 5 sampling train, 100 ml of 0.1N HNO_3 was placed in each of the first two impingers to facilitate collection of gaseous lead. Since no separation of gaseous and particulate lead was attempted, a filter, which was of high purity glass fiber, was located between the third and fourth impingers as a backup collector. After sampling was completed, the filter portion was extracted for lead in a nitric acid reflux procedure.

A rigourous pretreatment with HNO_3 of all sample-exposed surfaces and containers, blank analyses of filters and 0.1N HNO_3, and the most recent revisions of the Method 5 sample recovery procedure were all employed to insure that high quality samples were obtained.

Since emissions from the manufacture of lead batteries are relatively free of other pollutants, possible sample matrix effects associated with AAS were insignificant insofar as the impinger portion of the sample from this source was concerned. However, as a precaution against this problem with the filter portion due to the presence of the filter, the analytical technique known as the Method of Standard Additions was used for that fraction of the sample. In addition to lead determination, data were obtained by EPA at one plant on the formation process for sulfuric acid mist.

D.2 CONTINUOUS MONITORING

EPA has not determined performance specifications for opacity monitoring at lead battery plants. Opacity monitoring is, however, considered feasible, except when a wet scrubber is used to control lead emissions.

The equipment and installation costs for a single opacity monitor are estimated to be approximately $18,000 to $20,000. Annual operating costs, including data recording and reduction, are estimated to be between $8,000 and $9,000.

D.3 PERFORMANCE TEST METHODS

EPA Method 12 is recommended as the performance test method for lead emission from lead acid storage battery plants. EPA Method 9 is recommended for the determination of opacity. EPA Method 8 is recommended for the determination of sulfuric acid mist emissions.

EPA Method 12 is essentially the same method as was used in gathering the NSPS data, except that it has been revised to include all of the recent revisions to Method 5.

The cost of a test consisting of three lead runs with analysis and the determination of visible emissions is estimated to be about 6 to 8 thousand dollars. This cost estimate is based on the assumption that the testing is performed by independent contractors; the use of in-house or plant personnel will slightly reduce the cost.

APPENDIX E

ENFORCEMENT ASPECTS

E.1 GENERAL

The recommended standards of performance will limit emissions of lead from grid casting, lead oxide production, paste mixing, the three-process operation, and "other lead-emitting operations" and emissions of sulfuric acid mist from the formation process. The control systems that can be installed to comply with the lead standards are combinations of scrubbers and fabric filters. Scrubbers and mist eliminators can control formation emissions. The control system may serve one or several affected facilities simultaneously. Aspects of enforcing these standards are discussed below for each affected facility.

E.2 GRID CASTING

The design and operation of the grid casting units affect the level of uncontrolled emissions from the operation. Machine design is fixed and cannot be altered during tests. The casting operation is automatic, but each operator may control the temperature of his melting pot if there is not a central pot. During compliance testing, each pot should be at its normal operating temperature and all grid casting machines should be operating.

The rate of grid production is fixed by a constant machine speed. Thus, the operation of all machines indicates a maximum production rate.

Because of the units of the standard (gr/dscf), lead throughput data is not required. The process engineer should observe the process and record any operating problems that can affect compliance test results, such as breakdown of a machine or shutdown by the operator. A process monitor is necessary because production records alone may not be adequate to determine normal operation. The quantity of deformed plates produced generally is not recorded, but emissions are generated by the casting of both perfect and malformed plates. Thus, although production records may show a low production figure for the test day, the lead throughput during the test may be at a maximum.

Short downtimes during the test should not invalidate the results. It is often necessary to spray the molds with a special cork solution to prevent the grids from sticking. The process engineer will determine whether process downtime during the compliance test is excessive.

E.3 PASTE MIXING

Paste mixing is a batch operation done in a muller, day, or dough-type mixer. The process design for a given facility is fixed and cannot be changed during a compliance test. The paste mixing process involves two phases, materials charging and blending. Often each phase is controlled by a different device. At plants using two devices for the mixing cycle, the compliance test will require two different test locations. The tests should be performed only while the mixer is ducted to the control device tested. A process engineer can coordinate process operation with compliance tests.

Compliance tests should be performed while the mixer is operating at maximum load. Process operating records should be consulted to verify that the paste recipe during compliance tests is the one normally used at that facility. If the same mixer is used for both positive and negative batches, tests should be run during mixing of positive batches when possible. Typically more dry lead oxide is used in positive batches, since a wet lead oxide sludge (recovered from deformed plates) is often used in negative batches. The positive batches, therefore, may generate more lead emissions. The source tests performed in this study showed no significant differences in controlled lead emissions from mixing of positive and negative batches.

E.4 THREE-PROCESS OPERATION

The three-process operation consists of slitting and stacking, burning, and assembly. These functions are done in many different ways, as described in Chapter 3. Lead emissions depend on the process design, the materials-handling techniques, and the number of process steps. Compliance tests should be performed during full operation. It is not practical to require that all processes operate at all times throughout the tests, since a minor breakdown or a changeover in the type of battery being produced may require short downtimes that should not significantly affect overall process emissions. The process engineer must determine whether the downtimes of various three-process operations are significant enough to invalidate the compliance test.

In many three-process operations, one process may operate only if another process is shutdown. For example, a hand stacking station may operate only when an automatic unit is down or vice versa depending on the needs of the plant. If there is any indication that lead emissions from the two processes are significantly different, the process judged to generate the greatest amount of emissions should be operating during the compliance test.

Some plants may control different processes within a three-process operation facility with different control devices. In such instances, source tests must be run on all applicable stacks. Since it is likely that lead concentrations will be different in each exhaust stream, an equivalent concentration must be determined. This is done by determining total lead emissions in grains per minute and dividing by the total exhaust flow rate in dry standard cubic feet per minute. This equivalent concentration can then be compared with the standard.

E.5 LEAD OXIDE PRODUCTION

Lead oxide is produced by the ball mill and the Barton processes. Each must comply with the standard. The process is continuous, and equipment failures are few. If the equipment is just starting up after a shutdown, at least 4 hours of operation should be allowed before compliance testing to ensure that steady-state conditions have been achieved.

The lead oxide process may be controlled by more than one baghouse. The baghouses may or may not exhaust through a common stack. Only one test location is required if there is a common exhaust. Otherwise each stack must be tested. Proper baghouse operation can be checked by observing the pressure drop of the control device.

Lead emissions are proportional to the lead feed rate to the system. During compliance tests, the feed rate should be normal. If the feed rate varies significantly, tests should be performed during the maximum feed rate. The process engineer can monitor feed rate by counting the number of lead ingots fed to the system. The ingots typically weigh about the same.

E.6 LEAD RECLAMATION

The lead reclamation systems consist of a melting pot in which relatively clean lead is remelted and cast into ingots for use in the plant. This category does not include operations similar to those in the secondary lead smelters on the premises of a few lead-acid battery plants. Lead emissions depend on scrap feed rate, type of scrap, and operating techniques. Compliance tests should be performed at the maximum feed rate, while the "dirtiest" scrap is fed to the recovery process, and while operating techniques are normal. Since the lead reclamation system is on-stream only periodically, the plant must be notified well in advance so that enough scrap can be stored for all applicable tests.

Unlike most other lead-acid battery facilities, the operation of a lead reclamation facility is controlled mainly by the operator. The lead pot is usually heated continuously, but the temperature is raised from about 316°C to about 427°C (600°F to about 800°F) when scrap is being dumped into the pot. After dumping, the contents of the pot furnace is agitated with a metal rod so that the lead will sink. This can be done manually or automatically. Slag is removed from the surface periodically, and when there is room in the pot, more scrap is dumped in. The molten lead can be removed at any time and poured into molds. The process engineer can judge by observation whether the process is operating normally.

E.7 OTHER LEAD EMITTING OPERATIONS

Many lead-acid battery plants operate processes that are not common to all plants. A process such as lug breaking may be required at some plants because of the equipment used or the type of battery produced. Under the standard, such processes are required to be limited to lead emissions of not greater than 1.00 mg/m^3 (0.00044 gr/dscf). Compliance with OSHA regulations (50 $\mu g/m^3$) requires that all processes emitting significant lead emissions will be vented. These processes can normally be vented to controls serving other processes.